THE NUTRITION OF THE INFANT

RALPH VINCENT

FOURTH EDITION

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BY

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TO

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IN ACKNOWLEDGMENT OF HIS SCIENTIFIC

ACHIEVEMENTS, THIS WORK IS

Dedicated

BY THE AUTHOR

PREFACE

THE text has been carefully revised throughout, and much new matter has been added. Inasmuch as the milk-laboratory methods are not available at the present time for the great majority of infants, the 'fat-whey' method of home modification has been included in the chapter on Substitute Feeding. This method has been extensively used in the out-patient department of The Infants Hospital with extremely satisfactory results.

The chapters dealing with the bacteriology of milk and with the various forms of intestinal disorder have been practically rewritten, and numerous original photo-micrographs have been included.

The author desires to acknowledge his great indebtedness to the Treasurer of The Infants Hospital, Mr. Robert Mond, who has consistently supported the work of the Research Laboratory and has provided the costly apparatus by means of which the biochemical investigations have been carried out.

1, HARLEY STREET, LONDON, W.,
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NUTRITION OF THE INFANT

CHAPTER I

HUMAN MILK

HUMAN milk is a secretion of the mammary glands physiologically occurring at the beginning of the puerperium, and lasting for a period of about nine months, its precise duration being, however, dependent on a variety of circumstances. The physical characters of milk are peculiar; it is an emulsion, and at the same time a fluid holding solids in solution. The fat it contains is suspended as an emulsion in the liquid, so that when milk is kept in a vessel for some time the globules of fat rise to the surface.

Colostrum.—At the beginning of lactation the secretion of the mammary gland consists of a fluid distinctive in its character, and materially differing from normal milk. It is of denser consistence, yellowish in colour, somewhat turbid, and of a specific gravity varying between 1045 and 1065; its reaction is alkaline. It is generally distinguished in its composition by a comparatively low percentage of fat and a high percentage of protein. Microscopically the fluid is found to contain fat globules (which are generally smaller and less perfectly formed than those of milk), leucocytes, some of which are in a condition

of fatty degeneration, and bodies known as colostrum corpuscles.

Characters of Colostrum.—These bodies are 10 μ to 20 μ in diameter. Their protoplasm contains large and small granules, which give the protein reactions, and do not stain with acid, basic, or neutral dyes. Certain of the granules containing fat stain with osmic acid, but these are not present in large amount. Czerny describes these colostrum corpuscles as lymphoid cells, whose function is to absorb and reconstruct unused milk globules, and to carry them from the milk glands into the lymph channels.

Colostrum disappears as soon as normal lactation is established, or soon after. Occasional colostrum corpuscles may be present in the milk for the first fortnight.

Harrington analyzed five specimens of human colostrum, and the results are shown in the table below.

CHEMICAL COMPOSITION OF COLOSTRUM.

	I.	II.	III.	IV.	V.
Fat - - - - -	1·40	0·68	2·40	5·73	4·40
Milk-sugar and proteins - -	9·44	11·53	11·15	10·69	11·27
Ash - - - - - - -	0·17	0·31	0·25	0·16	0·21
Total solids - - -	11·01	12·52	13·80	16·58	15·88
Water - - - - - - -	88·99	87·48	86·20	83·42	84·12
	100·00	100·00	100·00	100·00	100·00

Woodward analyzed the milk of six women during the colostrum period, using in each instance the total amount of the middle milk for the twenty-four hours. His conclusions were that colostrum corpuscles are not invariably present, that when they are present the percentage of proteins is higher, and that with the disappearance of the colostrum corpuscles the protein percentage falls.

AVERAGE COMPOSITION OF COLOSTRUM.

		General Average of Twenty-six Analyses.
Colour	Yellowish	—
Reaction	Alkaline	—
Specific gravity	1024 to 1034	1029·5
Fat	2·0 to 5·3 per cent.	4·0 per cent.
Proteins	1·64 to 2·22 "	1·9 "
Ash	0·14 to 0·42 "	0 2 "
Total solids	10·18 to 13·65 "	12·5 "
Lactose	5·6 to 7·4 "	6·5 "
Water	-	87 5 "

These figures seem to indicate rather the character of milk in the colostrum period. After a few days the colostrum generally practically disappears. The pure colostrum found in the first few days is as a rule denser than is indicated by Woodward's average.

Transitional Period between Colostrum and Milk.—The character of colostrum milk, its changes and its disappearance, are shown by the observations of Adriance:[1]

CHARACTER AND VARIATIONS OF COLOSTRUM.

	Mother Twenty Years of Age.		Mother Nineteen Years of Age.		Mother Twenty-three Years of Age.	
	Three Days.	Six Days.	Two Days.	Ten Days.	Six Days.	One Month, Seventeen Days.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Fat	4·52	2·80	3·77	2·64	4·30	4·08
Lactose	5·86	6·83	5·39	6·62	5·38	6·91
Proteins	2·37	2·13	3·31	1·70	2·79	1·44
Salts	0·26	0·25	0·27	0·23	0·23	0·19
Total solids	13·01	12·01	12·74	11·19	12·70	12·62
Water	86·99	87·99	87·26	88·81	87·30	87·38

[1] 'Clinical Report on Two Hundred Cases of Human Breast Milk,' *Archives of Pediatrics*, vol. xiv., 1897.

The characteristic features of the colostrum are the low percentage of lactose, the excess of albuminoids and mineral salts, and, as a rule, the low percentage of fat, though, in regard to the amount of fat present, specimens vary greatly.

Townsend has shown that the shorter the colostrum period the smaller the so-called physiological loss of weight in the new-born.

It is frequently stated that colostrum has a laxative effect on the infant, and hence assists in the expulsion of the meconium. This, in the light of the author's experience, must be considered very doubtful. He has not seen any advantages in the infant from the ingestion of colostrum, and many of the disturbances of digestion in the first week are caused by the excessive amount present in the mother's milk.

Physical Characters of Human Milk.—During full lactation human milk is bluish-white in colour, its odour is characteristic, and the taste is distinctly sweet. Its reaction is invariably alkaline or amphoteric, and the specific gravity varies from 1028 to 1032.

Since the specific gravity is to some extent an index of the character of the milk, this point has received the attention of numerous observers. Vanderpoel and John S. Adriance[1] name 1030 as the average figure. Holt[2] finds that the specific gravity is usually between 1029 and 1032. Monti[3] assessed the average maximum at 1034, and the average minimum at 1030. Richmond[4] allows the narrow margin of 1030 and 1031 as the average. The above observations are in remarkably close agreement, especially when it is borne in mind that some of the specimens included in the observations were abnormal, if not pathological.

[1] *Loc. cit.* [2] 'Diseases of Infancy and Childhood

[3] 'Kinderheilkunde in Einzeldarstellungen,' Vienna, 1899.

[4] 'Dairy Chemistry,' 1899.

The specific gravity of human milk which may be regarded as typically normal is a remarkably constant figure. Specimens vary greatly in every respect, but those representing a normal milk, demonstrably capable of providing suitable and adequate food for the infant, though they still vary in composition, seldom exhibit any wide difference in relation to gravity.

According to the author's observations, 1030 may be regarded as the standard. Milks more than 1 below or above this figure usually present some abnormality, and frequently disagree with the infant. In comparatively exceptional cases milk may be of an altogether atypical character, while nevertheless adequately meeting physiological requirements. Yet even these cases seem to be in the nature of adaptations to a different standard, rather than direct aberrations from the normal. In illustration of this point, which is of some clinical importance, the character of the milk of elderly primiparæ may be cited. In these women the milk is often found to be distinctly abnormal when compared with the typical standard; but the specimens present similarities of constitution in regard to their physical and chemical character, enabling them more or less definitely to be placed in a class typical of themselves.

Specific Gravity and Chemical Constitution.—When, however, we have to deal with specimens exhibiting pathological features, and which have failed to provide the infant's requirements, the variations may be extremely wide. As low a specific gravity as 1017 has been recorded by Adriance, and as high a figure as 1036 has been found by him and by Johannessen. It may be doubted whether these figures represent the extremes of abnormality; but the features of demonstrably pathological milks need not detain us, since they are of curious rather than clinical interest. The variations within normal limits of the specific gravity are of great importance in enabling us to

estimate quickly, though approximately, the character of the food supplied to the infant.

From the fact that fat is of low specific gravity, and rises to the surface as cream when milk is left standing for some time, a high percentage of fat tends to lower the specific gravity of the whole. Hence, *cæteris paribus*, an excessive specific gravity of a given specimen of milk means a deficiency of one of its most important elements A milk of low specific gravity is often regarded as necessarily a poor one, whereas, in fact, the precise converse may be the case.

All the other solids, since their relative gravity is greater than that of water, increase the specific gravity in proportion to the amount present Of these the only ones of importance in relation to gravity are the albuminoids

The percentage of mineral salts present is too small to seriously affect the estimation, while the lactose is so remarkably constant that the variations due to this factor are so minute as to be almost negligible. These facts enable us to arrive at a generalization in regard to the probable constitution of a given specimen. Low specific gravity indicates excess of fat and deficiency of albuminoids; a mean specific gravity indicates a normal amount of fat and of albuminoids; a high specific gravity indicates an excess of albuminoids and a deficiency of fat. Though these facts may afford us some idea of the probable approximate constitution, the conclusions based on these would prove to be altogether fallacious in some cases—such, for instance, as in a milk containing a high percentage of both fat and albuminoids; for the excess of fat would counteract, in respect of gravity, the excess of albuminoids, and *vice versâ*. But with a knowledge of the specific gravity and of the percentage of either the fat or the albuminoids, it is possible to arrive at the approximate constitution of a given specimen.

Having regard to the clinical importance of a knowledge of the constitution of the milk in numerous cases of disturbed lactation, a method by means of which the character of the milk may be approximately estimated is often of value. The specimen for examination should be taken from the 'middle milk,' and it should be removed by means of the breast-pump, great care being taken to prevent undue handling and to ensure perfect cleanliness of the instruments. The specific gravity is then taken by

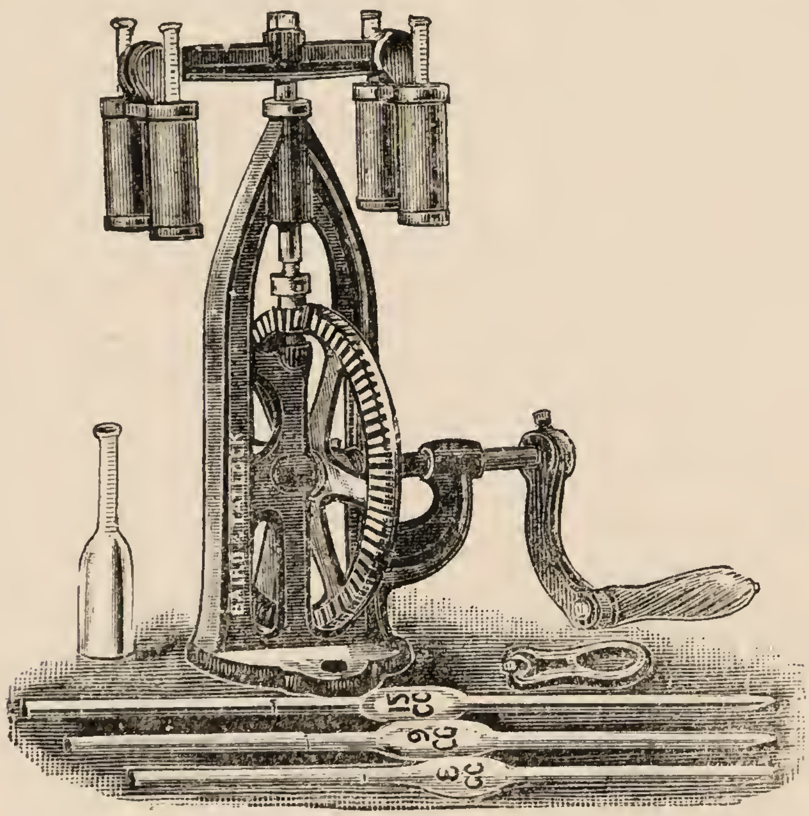

Fig. 1.—The Leffmann-Beam Apparatus.

means of a lactometer, and the percentage of fat is determined by the Leffmann-Beam method (after Babcock).

The determination of the amount of fat present in the specimen is carried out as follows:

Fifteen c.c. of the milk are placed in the special bottle; 3 c.c. of a mixture of equal parts of hydrochloric acid and amyl alcohol are mixed with the milk; 9 c.c. of sulphuric acid (specific gravity 1·842) are then added with agitation, and the bottle is filled up to the zero mark with a mixture of 1 part of sulphuric acid to

2 parts of water. The bottle is then revolved with a rotatory movement until the casein is completely dissolved, a dark purple-brown solution being formed. It is then whirled in the centrifugal machine for about one and a half minutes. The fat rises so that it occupies the neck of the bottle, and the graduations enable the percentage of fat present in the sample to be read off directly.

For the determination of the specific gravity an accurate lactometer is required, and the reading must be corrected for temperature. The following table gives the corrections usually required, as the sample to be examined can usually be brought within this range by means of running water.

Lactometer Degrees corrected for Temperature.

Lactometer Degrees at				
50° F.	55° F.	60° F.	65° F.	70° F.
1024·1	1024·6	1025	1025·5	1026·1
1025·1	1025·5	1026	1026·6	1027·2
1026·1	1026·5	1027	1027·6	1028·2
1027	1027·5	1028	1028·6	1029·2
1028	1028·5	1029	1029·6	1030·3
1029	1029·4	1030	1030·7	1031·3
1029·9	1030·4	1031	1031·7	1032·4
1030·9	1031·4	1032	1032·7	1033·4
1031·8	1032·4	1033	1033·8	1034·5

With the knowledge of the specific gravity and of the percentage of fat present in the specimen, certain general rules may be applied.[1]

1. If the percentage of fat is high and the specific gravity is also high (for instance, 1033 or 1034), we may assume that the albuminoids are present in large amount;

[1] These rules were first formulated for clinical use by Holt, 'The Clinical Examination of Breast Milk,' *Archives of Pediatrics*, vol. x., 1893, *et vide op. cit.*

otherwise the excessive fat would bring the specific gravity below normal.

2. If the percentage of fat is low and the specific gravity is high, the albuminoids are probably normal in amount, since the high specific gravity is explained by the low fat percentage.

3. If the percentage of fat is high and the specific gravity is low, the albuminoids are probably normal in amount, the low specific gravity being accounted for by the high fat percentage.

4. If both the fat percentage and the specific gravity are low, the albuminoids are probably below normal, else the specific gravity would be raised.

In the following table these conclusions are summarized:

Percentage of Fat.	Specific Gravity.	Probable Amount of Albuminoids.
High	High	High percentage.
Low	High	Nearly normal.
High	Low	Normal.
Low	Low	Deficient.

These rules necessarily only provide us with a rough approximation, and the precise constitution of the milk should in all important cases be determined by a complete chemical analysis. For clinical purposes, however, it is often necessary to obtain some knowledge of the character of the milk as quickly as possible, and in this respect, when used with discretion and judgment, the method is a valuable one.

Human milk consists of water about 87 per cent., of lactose about 7 per cent., of fat about 4 per cent., of albuminoids and other nitrogenous material about 1½ per cent., together with a small proportion of mineral salts amounting to about 0·20 per cent.

The product of the mammary gland varies greatly in different women, and in the same woman from week to week and from day to day, so that it is by no means easy

to arrive at a composition which may be regarded as typical of normal human milk. Moreover, in attempting to arrive at the figures which may represent the average composition, we are at once met with the difficult question as to what may be regarded as the limits of normal variation.

This question is one of the most prominent factors in the confusion of statements by many observers. Thus, for instance, Monti, in assessing the average percentage composition, includes in his calculations milks said to contain such high amounts that they must certainly be regarded as abnormal.[1] Another element of confusion is the tendency of writers to propound tables, either including or not including certain analyses of their own, but for the most part composed of the figures of other observers. By these means accurate observations cannot be improved, while the less accurate ones obscure those most exact. Hence, in endeavouring to arrive at the proper significance of any figures propounded, it is necessary for the student to be precisely acquainted with the actual factors of the assessment.

The inclusion of the observations of different observers is, of course, a perfectly legitimate proceeding and of distinct value, provided that the observers are all equally to be relied upon, and that the methods of analysis are either the same in all cases or may be regarded as equally accurate. On the other hand, the inclusion of inexact and discordant observations based on analytical methods proved to be inadequate can only give rise to unnecessary confusion and doubt.

Schlossmann's Analyses.—The results of 218 analyses of human milk were published in 1900 by Schlossmann.[2]

[1] 'Monti's maximum of 5 per cent. proteins must be considered an abnormally high figure' (Judson and Gitting's 'Infant Feeding,' 1902).

[2] 'Zur Frage der natürlichen Säuglingsernährung,' *Archiv für Kinderheilkunde*, Bd. xxx. (1900).

The large number of analyses, and the fact that the Kjeldahl method, probably the most exact, was used throughout, make this series extremely valuable, and the results must be accepted as, necessarily, more reliable than the analyses of earlier workers, which were based on less perfect methods. His figures are as follows:

TABLE SHOWING THE RESULTS OF ANALYSIS OF 218 SPECIMENS OF HUMAN MILK.

Number of Cases.	Days after Birth.	Fat.	Albuminoids.	Lactose.
6	9–10	4·23	1·81	6·92
25	11–20	4·63	1·81	6·89
41	21–30	4·53	1·94	6·77
21	31–40	5·00	1·50	6·97
13	41–50	5·41	1·75	6·80
24	51–60	4·62	1·56	7·28
10	61–70	4·69	1·44	6·94
19	71–100	5·39	1·25	6·77
25	101–140	5·10	1·25	6·94
15	141–200	4·02	1·29	6·89
19	Over 200	5·55	1·31	7·33

The average composition of human milk during the first seven months of lactation in regard to the amount of the lactose, fat, and albuminoids, is, according to these figures, as follows:

Lactose - - - -	6·95
Fat - - - - -	4·83
Albuminoids - - -	1·56

Schlossmann's account represents the results of extremely elaborate and detailed observations. Full particulars of the varying conditions, and of each case, are recounted in the original paper.

Differentiation of Proteins.—These analyses demonstrate that the protein percentage is high in the first weeks of lactation, and that this gradually falls during the continuance of lactation. In this series no attempt was made to estimate the relative amount of caseinogen and of the

whey proteins. In a previous analysis, however, Schlossmann found that, of the total albuminoids, 63 per cent. consisted of caseinogen, and 37 per cent. of lactalbumin. Lehmann and Bendix found the proportion to be 1·50 per cent. of caseinogen to 0·5 per cent. of lactalbumin. Monti and Camerer have stated that the proportion of caseinogen increases as lactation becomes more advanced. Monti makes the extremely important observation that during the first months of lactation the especial characteristic of human milk is the high percentage of lactalbumin relatively to caseinogen. König estimated the relative amount present in human and cow's milk by the following figures:

	Human Milk.	Cow's Milk.
Caseinogen - - -	0·59	2·88
Whey proteins - -	1·23	0·53
	1·82	3·41

Thus, the infant at the earliest period of life obtains the necessary protein material in the most digestible form.

As in many other observations, the fat-content is shown to be especially liable to variation. Schlossmann's figures for the fat-content are, however, remarkably high, the *lowest* being over 4 per cent. This is certainly surprising, and the present author knows of no other extended observations showing such a high minimum percentage as this. If we compare, for instance, these figures with the cases cited by Rotch (p. 22), the contrast in this respect is very marked. The explanation probably lies in the diet of the women. The fat in human milk is the one element most susceptible to the precise character of the diet, and it is much more easy, as a rule, to increase or diminish this constituent than any other. For these reasons we may regard Schlossmann's figures for the average fat-content (4·83) as somewhat too high for use as a general standard.

In regard to individual cases, this observer found that, in those cases in which he was able to continue observations over a long period, the compositions of the milk closely corresponded with the average deduced. He found the amount secreted to be in excess of that usually accepted, and estimated the total amount secreted in the twenty-four hours to be from 1,000 c.c. to 1,600 c.c. (from 35 ounces to 56 ounces). As a rule, the infant received too much rather than too little.

This confirms the author's experience, and there seem to be definite clinical facts in explanation of the tendency of the healthy mother to overfeed her infant. Women secreting too small an amount necessarily and obviously fail to adequately meet the requirements of the infant, and in these instances supplementary substitute feeding becomes essential. In a number of these cases the milk-supply from the mammary gland of the mother becomes less and less adequate, and the supplementary feedings require to be proportionately increased. In other instances the mother encourages the suppression of lactation when she finds she cannot entirely feed the infant, and that the substitute food satisfies it. When these cases of insufficient supply are excluded, since the defect is obvious, the commonest defect is one of quality associated with excess of quantity. As a rule (which, however, is not without many exceptions), a normal quantity of milk secreted in a normal period of time is an indication that its chemical composition is approximately normal.

Carter and Richmond's Analyses.—Ninety-four specimens of human milk, taken from women in the lying-in department of the workhouse infirmary at Birmingham, were analyzed by Carter and Richmond.[1] Their results are summarized as follows:

[1] 'Observations on the Composition of Human Milk,' *British Medical Journal*, January 22, 1898.

TABLE SHOWING THE COMPOSITION OF MILK IN CASES IN WHICH THE HEALTH OF THE INFANT WAS NOT GOOD.

Water.	Fat.	Lactose.	Proteins.	Ash.	Infant's Condition.
86·75	3·23	—	—	0·38	Infant died.
86·95	2·94	5·78	4·05	0·28	
87·48	4·13	4·80	3·11	0·48	Infant died.
88·01	1·22	8·89	1·55	0·33	Infant failing.
88·09	3·28	5·60	1·76	0·27	Infant vomiting.
87·72	3·33	6·63	2·05	0·26	
87 71	3·37	6·72	1·95	0·25	
87·11	3 96	5·40	3·19	0·34	Vomiting, diarrhœa.
88·82	2·39	7 03	1·50	0·26	Infant failing.
89·40	2·66	6·03	1·64	0·27	
89·54	0·87	5·19	4·02	0·38	Died.
89·39	1·87	5·74	2·65	0·35	
90·13	0·99	5·35	3·16	0·37	
88·45	2·10	6·55	2·54	0·36	
88·36	3·70	5·53	2·05	0·36	
87·57	4·71	4·87	2·47	0·38	
87·35	3·43	6·42	2·48	0·32	Flatulence, diarrhœa, colic.
88·29	2·16	6·70	2·52	0·33	
89·29	1·59	6·86	1·97	0·29	Strophulus.
89·31	1·02	6·81	1·98	0·28	
84·72	6·65	6·64	1·77	0·22	
82·93	8·82	6·29	1·74	0 22	
89·53	0·81	6·50	2·83	0·33	Pain, diarrhœa, vomiting.
88·95	1·48	6·45	2·79	0·33	
90·59	0·98	6·52	1·71	0·20	Supply deficient; infants died.
87·65	4·07	6·31	1·77	0·20	

The average constitution of milk that disagreed with the infants was:

Lactose - - - - -	6·28
Fat - - - - -	2·95
Proteins - - - -	2·36
Ash - - - - -	0·31
Water - - - - -	88·10

After eliminating all milks disagreeing with the infants, the average composition was found to be :

Lactose - - - -	6·70
Fat - - - - -	3·11
Proteins - - - -	1·83
Ash - - - - -	0·24
Water - - - -	88·12

In the following table is shown the results of their analyses of milk agreeing with the infant, subdivided according to the date of lactation.

TABLE SHOWING THE COMPOSITION OF MILKS AGREEING WITH THE INFANT.

Time since Parturition.	Lactose.	Fat.	Proteins.	Ash.	Water.
4 to 6 days -	6·47	2·97	2·25	0·30	88·01
7 to 14 days -	6·62	3·06	1·85	0·26	88·21
15 to 29 days -	6·95	3·42	1·67	0·22	87·74
Over 30 days -	6·83	3·00	1·43	0·21	88·53

As all these cases were in the workhouse infirmary, it may be assumed that the women were, in general, ill-nourished; this view is supported by the low fat-content. The average percentage of fat in the milks agreeing with the infant is nearly 1 per cent. below the normal standard, a diminution of about one-fourth of the usual amount of fat. In regard to the protein-content, the results of the analyses are in remarkable agreement with those of Schlossmann, as is also the case in reference to the proportion of lactose. Comparing the average composition as stated by Schlossmann with the average composition of milks agreeing with the infant as given by Carter and Richmond, there is a difference as regards lactose of 0·25 per cent., as regards the proteins of 0·27 per cent. That the total nitrogenous material present in normal human milk during the first six months of lactation is not less than 1·50 per cent., and not more than 2·00 per cent.,

is clearly established by these precise and independent observations.

The effects of disturbed lactation will be discussed later, but attention may here be drawn to certain features which are, as a rule, characteristic of abnormal or pathological human milk.

The fat-content is seldom excessive, and in most cases falls to a very low amount, while the protein-content is generally greatly increased. Taking the cases in which the milks proved to be unsatisfactory, the percentage of fat was above 4 per cent. in five cases; it was less than 3 per cent. in fourteen cases, and in nine instances under 2 per cent. On the other hand, the protein-content was almost invariably excessive. No case is recorded in these tables where the amount of protein can be regarded as pathologically deficient, while in fourteen cases the amount of the protein was over 2 per cent. These analyses are therefore instructive in demonstrating the features of pathological lactation, and they further illustrate the importance of the consideration previously advanced, that in arriving at the average composition of human milk it is important that pathological cases should be excluded. In certain cases of abnormal lactation the fat is excessive in amount, and in these cases this element may be greatly in excess, so that the proportion of fat is as much as 7 per cent. In such cases the infant is in danger of acute fat intoxication, especially if the amount of proteins is also excessive.

Söldner's Analyses.—A series of careful analyses were carried out by Söldner[1] in regard to the albuminoids and nitrogenous matter, after he had satisfied himself by control experiments that the Kjeldahl was the most reliable method. The breasts were completely emptied during the day, and during the night the infants were breast-fed.

[1] *Vide* 'Analysen der Frauenmilch,' *Zeitschrift für Biologie*, 1896.

TABLE SHOWING THE RESULTS OF SÖLDNER'S ANALYSES OF HUMAN MILK.

Days after Birth.	Albuminoids.	Unknown Extractives.	Albuminoids plus Extractives.
Colostrum, early	5·35	1·99	7·34
„ late	2·90	1·33	4·23
Fifth and sixth days	1·81	0·85	2·66
Eighth and ninth days	1·42	1·00	2·42
Ninth day	1·40	0·80	2·20
Ninth and eleventh days	1·61	0·42	2·03
Eleventh day	1·61	0·94	2·55
Fourth, fifth, and eleventh days	1·56	0·71	2·27
Twentieth and twenty first days	1·11	0·50	1·61
Twenty-ninth and thirtieth days	1·04	0·35	1·39
Seventy-fourth day	0·88	0·02	0·86
One hundred and thirteenth day	0·88	0·06	0·94
Two hundred and twenty-ninth day	0·81	0·01	0·82

It is clear from these investigations and from those previously referred to that in the older analyses the percentage of albuminoids was considerably exaggerated. Especial value attaches to Söldner's results, in consequence of his important differentiation between the albuminoids and the extractives. Camerer and Söldner consider that the average composition of human milk during the second week of lactation is represented by the following figures:

	Per Cent.
Lactose	6·50
Fat	3·28
Albuminoids	1·52
Citric acid	0·05
Extractives	0·78
Salts	0·27
Total solids	12·40
Water	87·60

V. and J. S. Adriance's Analyses.—120 cases were analyzed by Vanderpoel and J. S. Adriance.[1] The women

[1] *Loc. cit.*

were healthy, and were of an average age of twenty-five years; sixty-five were primiparæ, and fifty-five were multiparæ. The breasts were not completely emptied, but the specimens were in every case removed after the infant had been suckled for two minutes. The method used was the same as in the preceding series. Their figures are as follows:

TABLE SHOWING THE RESULTS OF 120 ANALYSES.

Days after Birth.	Lactose.	Albuminoids.	Salts.
Second to fourteenth day	5·80–6·63	2·77–1·70	0·27–0·20
One month - - -	6·68	1·58	0·19
Three months - -	6·72	1·44	0·18
Six months - - -	6·78	1·25	0·16
Nine months - - -	6·84	1·04	0·16
Twelve months - -	6·90	0·83	0·15
Fifteen months - -	6·96	0·63	0·14

These analyses again show the excess of proteins in the early weeks, and their gradual decrease in the later part of lactation. No mention is made of the nitrogenous extractives.

Mineral Salts.—The mineral matter present in human milk has been analyzed by various chemists, but, owing to the large amount of milk required and the difficulty of obtaining this, the definite results obtained in the case of cow's milk had not been obtained in the case of human milk. In 1893, at Rotch's instigation, a very complete investigation was carried out. In the course of a few weeks Rotch collected about 6 quarts of human milk. This milk was immediately reduced to its mineral constituents in Harrington's laboratory, and the figures below represent the results of the analyses of this mineral matter by Harrington and Kinnicutt:

THE MINERAL MATTER OF HUMAN MILK.

Unconsumed carbon	0·71
Chlorine	20·11
Sulphur	2·19
Phosphoric acid	10·73
Silica	0·70
Carbonic acid	7·97
Iron oxide and alumina	0·40
Lime	15·69
Magnesia	1·92
Potassium	24·77
Sodium	9·19
Oxygen (calculated)	6·16
	100·54

COMPOSITION OF THE MINERAL MATTER CALCULATED FROM THE ABOVE ANALYSIS.

Uncombined carbon	0·71
Calcium phosphate	25·35
Calcium silicate	1·35
Calcium sulphite	2·11
Calcium oxide	1·72
Magnesium oxide	1·91
Potassium carbonate	24·93
Potassium sulphite	8·04
Potassium chloride	12·80
Sodium chloride	23·13
Iron oxide and alumina	0·40
	102·45

The relative proportions of the salts in the form in which they occur in milk may therefore be approximately stated as follows:

Calcium phosphate	23·87
Calcium silicate	1·27
Calcium sulphate	2·25
Calcium carbonate	2·85
Magnesium carbonate	3·77
Potassium carbonate	23·47
Potassium sulphate	8·33
Potassium chloride	12·05
Sodium chloride	21·77
Iron oxide and alumina	0·37
	100·00

The most important differences between these and the older figures lie in the amounts of phosphoric acid, magnesium, silica, and alumina. The phosphoric acid and magnesium are less than half the amount previously recorded; the other two had not been discovered previously.

We are not yet in a position to make definite use of our knowledge of the character of the mineral matter, nor to state whether or not it has any practical bearings on nutrition, though it would appear probable that, within certain limits, a moderate excess is less to be feared than a marked deficiency. Elimination of any excess of salts is usually readily carried out by the kidneys and other organs, whereas it is to be presumed that radical deficiency would interfere with the due provision of the inorganic materials required for the structure of the tissues.

The above summary of the chemical constitution of human milk has been confined to the work of comparatively recent observers. König, Pfeiffer, and many others, carried out investigations of the most valuable character at a time when analytical technique was far less advanced than it is at the present time, and to these pioneers the greatest honour is due. But there can be little question that the older analyses were less accurate than the more recent ones, in consequence of the methods then available being less perfect. It would, therefore, only tend to confusion were these results blended with those of more recent date.

Bearing in mind the variations in human milk due to variations in the diet, in the external environment, and in the habits of women, together with differences resulting from the particular method of analysis, the observations of Schlossmann, Richmond, Söldner, and V. and J. Adriance, are in remarkable agreement in regard to the most important constituents of human milk.

Yet it must be admitted that the most perfect methods of chemical analysis at present known cannot tell us the

precise composition of human milk. The importance of Söldner's demonstration of the nitrogenous extractives can scarcely be exaggerated. On the eighth and ninth days of lactation he assesses the amount of these at 1 per cent., an amount equal to more than two-thirds of the albuminoid content. Other observers have not taken account of this element in their analyses, and it is clear that, in regard to the proteins of milk, we are dealing with bodies of the precise composition of which we know very little.

Hence it is important that, in the study of normal and pathological lactation, and in the practice of substitute feeding, the standard of normal human milk should always be our first consideration. Our ignorance of some of the chemical factors renders it all the more necessary that clinical observations should also receive their share of attention. As our knowledge of the ultimate constitution of milk is limited, it is important, especially in reference to substitute feeding, that this should be remembered. The natural conditions should be adhered to as closely as possible, and the methods of modification should be devised so that, as far as possible, chemical or physical alterations of the primal proximate principles may be avoided.

These considerations are the more important since the results of analysis by the most competent chemists and the clinical results of equally competent physicians are in some points conflicting. No physicians, least of all those most prominently identified with the study of the nutrition of infants, would be prepared to base their methods upon a principle involving a high protein percentage in the early weeks of life, and a gradually decreasing one as the infant developed ; yet if we were to be guided solely by chemical analysis, the results recorded above leave us no choice. In this connection it must be remembered that the function of lactation in the civilized mother is failing. Of the mothers who devote

themselves with great assiduity to the nursing of their infants, very few can maintain it for so long a period as nine months. Even if they are able to maintain the supply of milk, they find that, after a certain period, the infant fails to thrive. It may reasonably be assumed that the causes which have led to this result were established for some time prior to their observation or appreciation by the mother.

The Nitrogenous Constituents.—There can be little doubt that the extractives are nitrogenous in character, and they must play an important part in the nutrition of the infant. In regard to chemical analysis also, the precise character of the albuminoids has not yet been determined by analysis, though the observations of Schlossmann, Lehmann, Bendix, Monti, Camerer, and others, all tend to show that the especial characteristic of the albuminoids of human milk rests in the high proportion of those forms represented by lactalbumin in contrast to caseinogen.

Taking, therefore, the results of analytical and clinical observations in account, the following table may be regarded, in the author's opinion, as representing the nearest approximation to the constitution of human milk, at about the third month of lactation, which is as yet possible in reference to our knowledge of the various factors, it being understood that the nitrogenous extractives are included in the whey proteins.

THE APPROXIMATE CONSTITUTION OF HUMAN MILK AT THE THIRD MONTH OF LACTATION.

Fat	4·00
Lactose	7·00
Whey proteins	1·00
Caseinogen	0·50
Mineral salts	0·25
Water	87·25
	100·00

In regard to substitute feeding especially, the above figures represent the standard adopted by the author.

The various factors will be dealt with in detail in reference to this subject. It need only be pointed out here that, if the above figures in any way indicate the constitution of human milk, the methods of modification which consist in merely diluting cow's milk with water are open to grave objections, not only in reference to the character of the proteins present in the mixture, but also in the depreciation of nitrogenous materials present in solution in the whey.

Cow's milk contains a lower proportion of nitrogenous extractives than human milk, and it is therefore important that their amount should not be further diminished. One-eleventh of the total nitrogen in human milk is present in the form of extractives, as compared with one-sixteenth in cow's milk. It is probable that the degree of energy and vigour of the infant is largely determined by the amount of these extractives present.

In the later months of the infant's life—that is, after the sixth month—the advantages of whey are not so manifest, and in human milk at this period the amount of nitrogenous extractives appears to be small.

Clinical Evidence.—Though in the present state of our knowledge the methods of chemical analysis are insufficient to fully inform us in regard to all the factors of infantile nutrition, it is a striking fact that on the whole matter the most exact chemical and clinical observations are remarkably in agreement, and the study of the results of both methods of investigation throws more light on the subject than a study confined either to the one or to the other.

For it is as true of the infant as of the adult, that the element of the human individual demands the most complete recognition. No method of arbitrary rules, whether based on chemical or clinical observations, is likely to succeed.

Human milk is a food of varying composition, apart

altogether from pathological changes. Rotch's figures showing the composition of the milk of different women, all of them successfully nursing their infants, afford an instructive example of this.

HUMAN BREAST MILK ANALYSIS (HARRINGTON).

Mothers healthy, and infants all digesting well and gaining in weight.

	I.	II.	III.	IV.	V.	VI.	VII.
Fat - - -	5·16	4·88	4·84	4·37	4·11	3·82	3·80
Lactose - - -	5·68	6·20	6·10	6·30	5·90	5·70	6·15
Proteins - -	4·14	3·71	4·17	3·27	3·71	1·08	3·53
Mineral matter -	0·17	0·19	0·19	0·16	0·21	0·20	0·20
Total solids -	15·15	14·98	15·30	14·10	13·93	10·80	13·68
Water - - -	84·85	85·02	84·70	85·90	86·07	89·20	86·32
	100·00	100·00	100·00	100·00	100·00	100·00	100·00

	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.
Fat - - -	3·76	3·30	3·16	2·96	2·36	2·09	2·02
Lactose - - -	6·95	7·30	7·20	5·78	7·10	6·70	6·55
Proteins - -	2·04	3·07	1·65	1·91	2·20	1·38	2·12
Mineral matter -	0·14	0·12	0·21	0·12	1·16	0·15	0·15
Total solids -	12·89	13·79	12·22	10·77	11·82	10·32	10·84
Water - - -	87·11	86·21	87·78	89·23	88·18	89·68	89·16
	100·00	100·00	100·00	100·00	100·00	100·00	100·00

Here we see the fat varying between 5·16 and 2·02 per cent., and the albuminoids varying between 4·17 and 1·08 per cent. The content of total solids is as high as 15·15, and the minimum is less than 11 per cent. Some of these milks are altogether abnormal, as may readily be realized from the figures previously quoted. Serious results would generally ensue in the case of a young infant receiving a milk containing such high proportions

of fat and proteins as appear in some of these analyses. In many cases the digestive reactions would entirely fail in the presence of such an abnormal amount of food material. In the author's experience of cases where the infant has thrived on a milk containing unusual amounts of both fat and proteins, the amount of milk received has been much less than the normal amount.

Although these milks are all to be regarded as physiologically normal, because they answer the most practical test, they can only be so accepted in relation to the mother and her infant. The interchange of infants immediately resulted in gastric and intestinal disturbance.

In normal conditions a close relationship exists between the secretion of the mammary gland of the mother and the digestive and nutritional needs of the infant. Whether, therefore, the infant be fed by the natural method or by substitution, the factors of nutrition involved are of serious moment, and not to be dealt with or calculated by any rigid formulas. The adjustment of the diet of the infant, when this is required, is one which demands clinical and physiological precision, with a due regard for all the essential factors.

CHAPTER II

LACTATION

In the virgin the mammary glands, when fully developed, form two conical, almost hemispherical, eminences situated towards the lateral aspect of the pectoral region.

Each breast corresponds more or less closely in length to the interval between the third and seventh ribs, and in breadth extends from the side of the sternum to, or somewhat beyond, the anterior margin of the axilla.

The dimensions and general development of the breasts vary at different periods of age and in different individuals. Before puberty they are small in size, but become much larger and more fully developed in correspondence with the development of the reproductive organs. The left breast is usually somewhat larger than the right.

At its base each breast is nearly circular, and its outer surface is convex. Situated just below its centre is a prominent erectile structure, the nipple (mammilla), the surface of which is usually somewhat darker in colour. The areola surrounds the nipple, and is generally of a tint intermediate between that of the nipple and the breast. In fair women the areolæ may be of a delicate rose tint; in others the colour corresponds in depth with that of the hair and complexion.

The nipple is provided with papillæ, and is perforated at its summit by the orifices of numerous lactiferous ducts. The areola is studded with rounded eminences

(Montgomery's glands) which become much enlarged during lactation. These glands secrete a sebaceous material, which lubricates the nipple so that it may be kept supple.

The breast structure consists of gland tissue supported by fibrous tissue. Interposed between the lobes is a considerable amount of adipose tissue. The gland tissue is pale red in colour, circular in shape, flattened from before backwards, and thicker at the centre than at the circumference.

It consists of numerous lobes, which are subdivided into extremely numerous lobules. The smallest lobules are composed of a cluster of vesicles opening into the branches of the proximal ducts. These ducts, uniting, form large tubules which terminate at the orifice of the nipple. The number of these main ducts is about fifteen to twenty, and they are termed the 'tubuli lactiferi.' They all converge towards the nipple from the various sections of the gland, and immediately beneath the areola are dilatations of the ducts, termed 'ampullæ,' which serve as reservoirs for the milk. At the base of the nipple the ducts again become contracted, and their orifices at the summit of the nipple are appreciably smaller in diameter than the ducts.

These tubuli lactiferi are lined with a single layer of columnar epithelium, except at their orifices where the epithelium resembles that of the squamous type. In appearance the alveoli differ greatly, according to the precise condition of the gland. Each alveolus consists of a basement membrane lined with a single layer of cells, having a wide lumen when the alveolus is empty. Foster[1] describes the two typical phases of the gland as the loaded and the discharged.

The Discharged Phase.—In the discharged phase the alveolus is lined by a layer of flattened cubical cells, so that the relatively large area of the alveolus is almost

[1] 'Text-Book of Physiology.'

wholly occupied by its lumen, in which some of the constituents of milk may be retained. Each cell is composed of granular cell substance, in which is placed a rounded or oval nucleus. Sometimes the free edge of the cell is jagged and uneven, as if a portion of the free border had been torn away.

The Loaded Phase.—In a fully loaded phase the appearances are very different. The alveolus is lined with a layer of large cells, columnar in type, which project unevenly into the lumen, so that its area is much diminished and its outline is irregular. The cells contain two or more nuclei; the one near the base of the cell is well formed, while the others, near the lumen of the alveolus, show signs of degeneration. Occasionally constrictions are seen between the basal and peripheral portions of the cell, and detached cellular fragments are found in the lumen. In the cell substance, particularly in the peripheral portion, are numerous fat globules, and the larger ones project from the border of the cell. In addition to this extrusion of fat, the cellular substance itself breaks down and is thrown into the cavity of the alveolus. This cellular degeneration is apparently much more marked at the onset of lactation than when it is fully established, and probably accounts for the peculiar characters of colostrum.

Development of Breasts in Pregnancy.—From the onset of pregnancy, the breasts undergo a remarkable development. They become fuller and firmer, the nipples are much more prominent, and their erectility is greatly increased. The blood-supply is plentiful, and the full veins proceeding from the breasts form a network between the breasts and in the region of the upper part of the sternum. In a primipara, especially, these developments are so striking that they form a prominent feature in the diagnosis of early pregnancy. The chief development is in the glandular tissue; this becomes hard and nodular,

and much more definitely palpable than in the virgin. At about the tenth week of pregnancy a mucoid secretion forms in the gland, and, gradually oozing from the nipples, forms dried crusts which adhere with some tenacity to the superficial epithelium.

Gradually the nipples and areolæ darken in colour; in fair women these changes may be slight, whereas in brunettes the depth of the pigmentation may be very marked. The areolæ become elevated above the surrounding skin, and Montgomery's glands become hypertrophied. At a later stage, about the fifth or sixth month, a secondary areola in the shape of irregular pigmentation of the skin over the breast frequently occurs.

At the end of pregnancy the breasts are almost empty, save for a small amount of colostrum. In the course of three or four days they rapidly fill, and by the end of the first week lactation is fully established. In the first few days the fluid secreted is almost entirely colostrum. At the end of this period this secretion is replaced by milk; but for some time, not infrequently for as long as fourteen days, traces of colostrum may be found in the milk. In correspondence with the needs of the infant, the amount of milk secreted is at first small in amount, and gradually increases to meet the greater demand; while at a later period the activity of the gland begins to wane, so that the mother can no longer supply her infant with sufficient food.

Management of Lactation.—The proper management of lactation is of the greatest importance in regard to the health of the infant, and, in a great majority of cases where breast-feeding has to be prematurely given up after having previously proved to be quite satisfactory, this failure is the result of inadequate care. The mammary gland of the woman is exceedingly sensitive to both favourable and adverse conditions, and by the neglect of due precautions a milk fulfilling all the requirements may

be speedily converted into a milk of a quite different character, with the result that the infant is at once in danger. On the other hand, it is far too frequently assumed in such cases that the disorder in the infant demonstrates that the mother is unable to nurse her infant. In many cases, adequate regulation of the diet and exercise, and of the other factors involved in healthy lactation, results in the milk becoming normal in quality and suited to the infant's digestion.

Contra-indications to Lactation.—At the outset it must be determined whether it is advisable for the mother to attempt to suckle the infant. The reasons for forbidding this fall under two heads: those for the sake of the mother and those for the sake of the infant.

The presence of tuberculosis in any form, the presence of any symptoms or signs suggesting the possibility of tubercular affection, the fact that the mother comes of a stock disposed to tuberculosis, or possesses the facies and general appearance of one predisposed to this disease, should be considered absolute contra-indications to her undertaking the task of suckling her infant. Nothing assists the progress of the disease or renders its incidence in predisposed subjects more likely than lactation. Its effect in this respect is so great that, frequently, when nursing is undertaken and the disease is present, severe damage is done in a few weeks. The condition of the woman is altered altogether, and she becomes the subject of the infection in its acute form.

As to how far maternal nursing in these cases is a danger to the infant is as yet undecided; but the danger to the mother is so great that this question is of no practical importance.

The presence of chronic disease, such as chronic parenchymatous nephritis or any other disease entailing a serious weakening of the general organism, should again be an indication that maternal nursing is dangerous. The

mother should not be allowed to suckle her infant if she has suffered greatly during pregnancy—as, for instance, from chronic vomiting, or where exhausting complications have occurred immediately prior to, during, or after labour. Nor should nursing be permitted when any definite disease of the nervous system, either functional or organic, is present.

In cases of the above character, the duty of the medical adviser is clear, but in addition to these there is a large class of cases in which the advice to be given must depend on his judgment and upon the individual factors of each case. Nervous or neurotic women make bad nurses. The complications of lactation, in regard to emotional disturbance, will be more particularly discussed later; here it need only be said that extremely nervous women are only at all likely to be able to provide a suitable food if they are carefully and systematically tended, so as to protect them from everything in their possible environment likely to disturb them. It need hardly be said that in many instances this is extremely difficult, if not impossible.

Or, in other cases, the mother may be so frail and delicate of structure as to render any additional strain upon her organism inadvisable. Finally, it should be remembered that, while maternal nursing is the ideal method, it is a mistake to practically force a really unwilling mother to undertake the suckling of her infant. Many young mothers, not unnaturally anxious to avoid the severe restrictions and disabilities nursing imposes, are unwilling to accept the duty. But when the importance of breast-nursing by the mother is properly put before them, they cheerfully accept the duties and bear with the inconvenience. On the other hand, it is seldom wise to urge the duty upon a mother when there is little prospect that she will properly discharge it. It has frequently been necessary for the author to place an infant upon substitute

feeding, not because the mother was unable to feed her infant, but because the life she led resulted in the infant receiving a milk quite beyond its powers of digestion. Where it is possible to foresee such conditions, it is far safer that the infant should be substitute-fed from the beginning, rather than that all sorts of digestive disturbance should be created by its mother's milk, with the consequence that the re-establishment of the normal digestion is attended with delay and difficulty. In these cases the most that it is judicious to attempt is to induce the mother to nurse her infant during the first month of the puerperium.

Although the supply of milk may be plentiful, it may be of poor quality, so that the infant does not receive adequate nourishment; while in other cases the secretion of milk may be small or entirely absent, so that maternal nursing is impossible. Quite apart from the willingness of the mother, it is a fact that the capacity for maternal nursing among the more cultured classes of women is steadily decreasing. Cases are constantly coming under observation where the mother is extremely anxious to nurse her infant, and is fully prepared to make every sacrifice in order that she may be able to do this; but the milk provided by her is either so small in amount or so poor in quality as to render maternal nursing out of the question. It is a great mistake to encourage these mothers to persist in the attempt when the task is clearly beyond their powers, and great harm to the infant often results from an unreasoning adherence to maternal nursing. The increasing inability of women to nurse their infants, due undoubtedly to the effects of high civilization, is widespread and calls for adequate recognition. Holt of New York has drawn attention to his experience in that city.[1]

[1] 'In New York at least three children out of every four born into the homes of the well-to-do classes must be fed at some other font than the maternal breast. The percentage of successful maternal

Regimen of Lactation.—In those cases where breast-feeding is to be undertaken, due precautions must be observed both prior to and during lactation to ensure, as far as possible, the supply to the infant of milk of good quality and in sufficient amount. Everything must be done to maintain the mother in a perfect condition of health. She should have a plentiful supply of nutritious food in a form easy of digestion, and, in order to prevent intestinal disorder, it is usually wise, in the last month of pregnancy, to place the mother upon a more or less systematic dietary, in which unsuitable foods, condiments, etc., are directly forbidden.

Exercise in the shape of walking is important, and, unless contra-indicated, should always be insisted upon, as the absence of a proper amount of muscular exercise is prejudicial to the character of the milk. On the other hand, anything in the shape of excitement or fatigue should be especially avoided, and the mother should be encouraged to rest quietly after taking exercise.

Nervous Influences.—The nervous system should be stable and of good tone. Unrest, excitement and worry are all extremely prejudicial to efficient lactation, and where they are well marked and the mother is impatient of control the prospects of successful maternal nursing are far from favourable. While it is generally advisable that moderate exercise be taken daily, there are some exceptions to this rule. In the last weeks of gestation some women show manifest signs of exhaustion. In such cases, unless the symptoms are treated, serious complica-

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nursing is steadily diminishing every year, and even now an educated mother who successfully nurses her own infant for six months is a phenomenon, and one who can continue it for ten months almost a curiosity. . . . It is not, as has been so often asserted, that the modern mother will not nurse; nearly all in my experience would be glad to do so if they could, but they simply cannot.'

tions may arise. Exhaustion towards the end of pregnancy is an unsatisfactory feature, both with reference to lactation and to other factors of the puerperium, and calls for a thorough investigation. In all cases the patient should remain entirely in bed until all signs of disorder have disappeared, and especial care should be taken of her during and after pregnancy.

Care of the Breasts.—The condition of the breasts requires careful attention from about the third month of pregnancy. The mammillæ should be kept quite clean, and should be occasionally bathed with hot water, in order to effect the removal of the crusts which form on the surface as the result of the drying of the secretion which oozes from them.

If, in a young primipara, the breasts be unduly large from excess of adipose tissue, gentle massage of the breasts may be of great service by increasing the local circulation, and thus removing the superfluous fat. This point is not without its importance: women with breasts loaded with fat are seldom able efficiently to undertake maternal nursing. The comparatively small but firm breast is, as a rule, much more efficient, as in this form the glandular element is more active.

In addition to the careful cleansing of the nipples, attention is necessary to ensure their being sufficiently supple; if they are too dry, they should be gently and regularly anointed with lanoline in order to replace the deficiency of the sebaceous secretion. Anything tending to cause pressure of the nipples must be avoided, since this is likely to lead to retracted nipples. If the nipple is ill-developed or retracted, much can often be done by the patient herself to counteract this. She should be instructed to systematically draw out the nipple from the breast with her finger and thumb, lanoline being used as a lubricant to prevent chafing. Manipulations of this kind, when properly carried out, will frequently result in the forma-

tion of a nipple of proper size and sufficiently pliable, when previously the nipple was hard, small, and much retracted. The use of spirituous applications, such as eau de Cologne or methylated spirit, with the view of hardening the nipples, is seldom to be recommended. In certain cases, where the tissue is too soft and without tone, these may be useful, but in a first pregnancy they are seldom indicated, and they tend to cause fissures and excoriations as a result of the ensuing brittleness. Where the secretion is abundant, as in some instances during the last month of gestation, absorbent dressing should be applied to prevent chafing and irritation of the nipples and adjacent skin.

Pregnancy Corset-Belt.—Suitable support for the breasts is of the greatest assistance to the pregnant woman, and in the pregnancy corset-belt recommended by the author due provision is made for this. At the back this corresponds closely to an ordinary corset, being shaped, boned, and laced in the usual manner. In the front, however, it is quite different from either the ordinary belt or corset. The breasts are supported by an elastic net, while the abdomen is supported by a shaped belt made of many pieces of elastic ribbon sewn together; this is laced at both sides to permit of the gradual increase in size. Light shoulder-straps are attached above, and suspender ribbons below. The whole thus gives a firm but elastic support, and allows of free movement without getting out of position.

The Diet of Lactation.—In regard to the diet suitable for lactation, there is considerable divergence of thought and practice; by some, great reliance appears to be placed upon the efficacy of certain foods and drinks in helping to produce a 'good milk.' As a matter of fact, the specific effect of diet is not marked in regard to lactation. Baumm and Illner made careful observations on the influence of

the food taken by the mother on her milk. Various nursing women were fed on the following diets:[1]

1. An ordinary mixed diet taken in great abundance.
2. A highly nitrogenous diet—*i.e.*, one containing much cheese, eggs, and meat.
3. A rich diet in carbohydrates and fat, but poor in nitrogen—*i.e.*, plenty of bread, farinaceous foods, sugar, and butter.
4. A very fluid diet.
5. An ordinary diet plus 2 to 3 pints of lager-beer daily.
6. A diet consisting largely of salt fish, pickles, and other salt foods.

The milks were systematically analyzed, and they found that fat was the only ingredient of the milk on which the diet produced any appreciable effect. It was increased, sometimes rising 1 per cent., on the first and second diets only. Neither an abundant supply of carbohydrates nor even an increased amount of fat increased the amount of fat in the milk. In fact, the diets containing excessive amounts of fat seemed to lead to a lessening of the percentage of fat in the milk. It is also stated that neither the increase in the fluids taken nor the excess of salted foods led to any appreciable alteration in the milk. These experiments with the sixth diet must certainly have been conducted in women with vigorous digestions; otherwise severe alterations would have been experienced, arising from disordered digestion in the mother. It is, however, clear that the fat present in human milk is not necessarily derived from fat taken in the food of the mother. In the case of cows fed on grass, their milk yields a great deal more fat than can be found in their food. It may be further pointed out that the rigid diet so often insisted upon in the case of nursing mothers, to the exclusion of

[1] Baumm and Illner, *Samml. Klin. Vorträge* (*Gynäk*), xli., 1894.

vegetables, fruits, etc , is not justified either by experimental investigation or by clinical results.

Alcohol in Lactation. — Alcohol in some form is frequently recommended to the nursing mother. Various observations have been made on the effect of alcohol on the secretion of milk, with the general result that no definite or specific effect can be attributed to it. Some experiments by Klingemann, in relation to the excretion of alcohol, are interesting. Two women each took 13 ounces of sparkling wine containing 12 per cent. of alcohol; two other women each took 11 ounces of port containing 18 per cent of alcohol. On analyzing the milks no appreciable amount of alcohol was found in any of the cases. From these and other observations it is clear that alcohol is not excreted by the mammary gland unless the woman take such an amount as to produce a state of intoxication.

In regard to lactation itself alcohol is of no value, and we are only justified in recommending it when its specific effect in the woman is to be desired. As an aid to appetite, and, in small quantity, a stimulus to digestion, it may be of great value. In such cases alcohol should be specifically prescribed in definite quantity at definite times. The routine administration of stout or other form of alcoholic liquor is certainly not to be recommended. In many cases it is decidedly injurious to the woman, especially when it interferes with, rather than aids, her digestion. It is also apt, when at all freely taken, to replace food, and thus interfere with the full supply of nutriment.

General Rules of Diet.—There is no special form of diet which can be recommended, and the best results will be obtained by adapting the diet to the individual requirements and idiosyncrasies of the nursing mother. So long as she is in bed after her confinement, or remains confined to her room, the diet should be light, and meat should

be of small amount till she is able to take exercise. A moderate amount of pure fresh milk of good quality is important, together with fish, chicken, eggs, bread-and-butter, etc., with such vegetables as can be taken by her without affecting the quality of the milk or disturbing the infant.

In reference to potatoes and green vegetables, some care is necessary, as, unquestionably, in certain cases the infant is upset when the mother eats these; but it is a great mistake to arbitrarily forbid these, as in the majority of cases they can be taken in reasonable amount by the mother without producing any such effects. It is much better, therefore, to allow these to be taken at first in small quantity; and if any bad effect follows, the particular vegetable or other article of diet responsible must be altogether prohibited, or its consumption regulated according to the needs of the case.

Exercise.—Probably exercise is a more important factor than the precise diet. So soon as the mother is sufficiently convalescent, she should be encouraged to walk about her room and to systematically develop muscular activity by various forms of exercise. In this respect calisthenic exercises and the use of very light dumb-bells are to be recommended. Later on, daily walking exercise to the point of moderate fatigue is of the greatest value in assisting the mother to provide her infant with a suitable milk. But here it must be admitted that the needs of the mother and of her infant are often opposed to each other. In the experience of the author amongst gently-nurtured women, any form of fatiguing exercise is directly detrimental to the process of involution and its effective consolidation, and this factor must be borne in mind in determining the degree and nature of the exercise to be recommended. Where walking is considered inadvisable, general massage is of great value in replacing this to some extent.

Effects of Drugs.—The greatest caution is necessary in regard to the administration of drugs to the nursing mother. It is impossible to lay down definite rules as to what drugs may not be administered, if they are to be of universal application. In one case, for instance, the mother may be able to take the liquid extract of cascara sagrada without the slightest effect on the infant; in another the infant may suffer greatly. The saline cathartics almost invariably act on the infant when administered to the mother. In the author's experience, castor-oil is the only purgative that can be administered to the mother without fear of detriment to the infant; in rare instances even this drug appears to produce some temporary disturbance. It should be remembered that any drug is more likely to be transferred to the infant if lactation be disturbed than if it be normal. The list of drugs capable of affecting the infant through its mother's milk appears to be very extensive, so much so that it would perhaps be more convenient to name those that were not so transferable.

Of the clinical facts in connection with the administration of drugs to the mother and their influence on the infant, the author has little or no experience, except with regard to purgatives. For if the mother is not well and systematic medicinal treatment is indicated, then this is an indication for the suspension or termination of lactation.

Regulation of Breast-feeding. — In all cases the success or failure of maternal nursing must largely depend upon the way in which the practical details are carried out. Where the methods are haphazard, and the mother feeds her infant at all sorts of times, sometimes overfeeding and at other times underfeeding it, the results are always unsatisfactory, and the infant is constantly suffering from digestive disturbance in some form; while in other cases the effects are much more serious.

Twelve hours after birth the infant should be put to the

breast and allowed to suck for two or three minutes. From this time to the time that the breasts are freely supplying milk, the infant should be given the breast every four hours. This stimulates the breast to secrete, enables the infant to obtain a certain amount of colostrum, and perhaps stimulates the contraction of the uterus, though in regard to this point the author must confess that his experience does not lend any support to the theory.

It is far from advisable to allow the infant to remain practically unfed for three or four days because its mother is unable to provide it with food, and it is a serious mistake to allow the infant to take freely of the colostrum when this is plentiful. In anything but a small amount, colostrum seriously disturbs the infant—a fact that is not at all surprising when its chemical constitution is considered.

Preliminary Feedings.—At the end of the first twenty-four hours a normal infant of average development may, with advantage, be fed on a substitute food until its mother is able to nurse it. The composition of these preliminary feedings should be approximately as follows:

	Per Cent.
Fat - - - -	2·00
Lactose - - - -	5·50
Whey proteins - -	0·50
Caseinogen - - -	0·15
Alkalinity - - -	5·00

Ten feedings, each containing 1 ounce.

This early feeding prevents, partially or completely, the preliminary loss of weight, and more firmly and quickly establishes the vigour of the infant. In those cases where lactation is delayed or is inadequate, or where it is found advisable to suppress it, the advantage of this course is obvious. Where breast-feeding is undertaken in the ordinary course, the preliminary substitute feeding serves as an excellent introduction, so that symptoms of indigestion and flatulence, resulting from the first ingestions of

breast milk, are much less frequent than when the infant is practically starved until lactation is established.

Nursing Intervals.—As soon as the process of lactation is fully developed, the infant should be fed every two hours in the day, and once at night. At about the sixth week the interval between the day feedings should be increased to two and a half hours, and may then be allowed to remain the same until the infant is about twelve weeks old, when it need only be fed, in the day, every three hours. At about this period, also, the night feeding should be omitted. It is important that the infant should be so trained that the night feeding becomes unnecessary as soon as possible. A great deal in this respect can be done by an able and intelligent nurse; it is clearly to the advantage of the mother that she should not be disturbed in the night, and it is equally beneficial to the infant that its mother obtain the necessary rest.

The table below represents the intervals generally advisable, but it must always be understood that precise rules to apply to all infants cannot be formulated. A vigorous infant weighing 8 pounds at birth, and an infant born at full term weighing but 6 pounds, and 1 inch short in length, are very different individuals, and they require individual treatment; but whatever be the intervals and the regulations of feeding, they must be regular and systematic if they are to be attended with success:

INTERVALS OF FEEDING.

Age.	Intervals.	Total Number of Feedings.	Night Feedings.
First days - - - -	4 hours	6	1
First 6 weeks - - -	2 ,,	10	1
From 6 to 8 weeks -	2½ ,,	8	1
From 2 to 4 months - -	2½ ,,	7	0
From 4 to 10 months -	3 ,,	6	0

Effects of Irregular Nursing.—When the mother nurses her infant at too short intervals, the proportion of total solids in her milk is increased, and when the intervals are unduly lengthened the increase in the amount of water renders the milk insufficiently nutritious, so that she is supplying her infant with a too dilute milk at too long intervals. As Rotch well says, irregularity in nursing, too frequent nursing and too prolonged intervals so disturb the quality of human milk as to transform a perfectly good milk into one entirely unfitted for the infant's powers of digestion.

Complications of Breast-feeding.—The infant must not be allowed to feed rapidly; the breast-feeding on each occasion should extend over fifteen or twenty minutes. At the beginning of feeding the infant is hungry and eagerly gulps down an excessive amount unless restrained; this rapid feeding is a common cause of digestive disturbance. In order to prevent the incidence of parasitic stomatitis and other disorders due to the development of micro-organisms, the nipple and the mouth of the infant should be cleansed both before and after feeding, and for this purpose nothing is better than warm water. A dilute solution of boracic acid may be used if considered desirable; but it presents no advantages over plain water, and if a stronger solution is used it is likely to upset the digestion of the infant from some of the salt reaching the stomach. The solution of boracic acid acts as an astringent, and the frequent application to the nipples is likely to result in injury of the epithelium and consequent abrasion. In the case of the infant, parasitic stomatitis never develops unless milk remains stagnant in the mouth, thus providing a nidus for the development of the *Saccharomyces albicans*. If the infant regurgitates its food, the mouth must be cleansed on each occasion, as the infection frequently arises from decomposition of the regurgitated food, rather than from traces of milk left in the mouth immediately after nursing.

Fissures and Excoriations.—Of the local complications of breast-feeding, the most frequent is sore nipples; and trivial as the affection may appear, few complications are so distressing to a mother anxious to nurse her infant. When a fissure is present, the pain caused by the sucking of the infant may be so severe that the mother is distracted by the conflict between her desire to nurse her infant and her inability to bear the pain it causes her. For the cure of this condition a large number of preparations are recommended; but it is useless to attempt the treatment of the condition, if the infant is to be allowed to nullify all treatment by its vigorous sucking every few hours.

In all cases where the excoriation or the fissure is at all severe, the infant should be removed from the breast for twenty-four or forty-eight hours. This is the first essential to success. The nipple should then be bathed with hot water and dusted with boracic acid; continuous wet dressings are especially to be avoided. The milk should be drawn from the breasts by the breast-pump at the proper intervals, and the infant fed with this milk from a bottle. Orthoform is much more efficacious in annulling the pain than boracic acid, but it has the great disadvantage of being liable to cause extensive dermatitis. In one instance where this drug was used very freely, gangrene of both nipples ensued. An account of this case was published by the author in the *Lancet*.[1]

When the nipple has sufficiently healed, the infant may be returned to the breast, with the interposition of a glass nipple-shield. In the worst cases it may be necessary to continuously use the breast-pump and to permanently inhibit direct sucking. This method is quite simple, and is much better practice than to allow the condition to recur again and again, with the result of great distress to the mother, and very probably of disturbance of the infant,

[1] 'A Case of Gangrene of Both Nipples occurring in the Puerperium,' *Lancet*, April 5, 1902.

from injury to the milk consequent upon the nervous exhaustion of the mother.

Other local conditions, such as mastitis, may interfere with suckling. Abscess of the breast is occasionally a complication, but the author has never seen a case except where maternal nursing was, and had been for some time, absolutely contra-indicated. Where such a condition is threatening, the suppression of lactation for the sake of both mother and infant is absolutely indicated.

Lymphangitis Mammæ.—An interesting complication of the puerperium was first described by the author in 1902, under the name of 'lymphangitis mammæ.'

The condition arises about the tenth day of the puerperium. About this time a pink flush may be seen on some part of the breast; this gradually develops, and in the course of twelve hours the following clinical picture presents itself: There is a wedge-shaped area of inflammation, the apex being at the nipple, the base being at some part of the junction of the breast with the chest wall. This wedge-shaped area is red, slightly œdematous, hot to the touch, tender, and indurated, the induration being distinctly outlined and definitely corresponding with the redness. The inflamed area is raised above the general breast surface, but the inflammation is confined to the superficial structures, and does not involve the mammary gland.

During the development of this condition the temperature rapidly rises, the patient complains of pain in the breast and of headache, while constipation is frequently present. The treatment required is simple: The infant is taken from the breast, hot fomentations are applied to the inflamed part, and the patient is freely purged. Within about forty-eight hours the affection has disappeared. For an account of the cases and of the etiology of the condition, the reader is referred to the original description.[1]

[1] 'Trans. Obst. Soc. of London,' vol. xliv.

To those not familiar with the clinical characters of this typical condition, the local and general signs are somewhat alarming, as may be gathered from the above description.

Various difficulties arise in maternal nursing from ill-developed nipples, from weakness of the infant, so that it has not the necessary power to suck, or from congenital malformations, as in the worst cases of hare-lip and cleft palate. In these cases it may be necessary to use the breast-pump and feed the infant with its mother's milk from a bottle or spoon. In others a nipple-shield may be of use, or some other mechanical device suited to the character of the particular case may be required. The fact that the physical act of suckling is impossible or is inadequate should not be considered a reason for depriving the infant of its natural food. The complications of lactation due to the mother's inability to supply a milk of a character suited to the requirements of her infant require separate consideration. Two conditions which may occur during lactation need especial consideration in view of their effect on the mother, and consequently on her milk.

Catamenia during Lactation.—The onset of menstruation in a nursing woman may be attended with no signs indicating an alteration of the character of her milk; it may be attended with obvious signs for a day or two, which, however, quickly disappear, and are scarcely at all marked in the succeeding periods.

In other cases the disturbance is acute, the character of the milk is radically altered, and from the onset of the catamenia the woman becomes completely incompetent as a nurse. It is therefore impossible to lay down any rule applicable to all cases. Menstruation sometimes appears about the third month after labour, and does not appear again for some months. Disturbance of the infant in these cases is, as a rule, either slight and evanescent or altogether absent.

Where the catamenia are found to have become regularly established, it is the more necessary to determine the effect on the infant. In highly nervous women the alterations may be severe, and weaning of the infant forthwith is indicated; in others it may be advisable to feed the infant by substitution during the menstruation, and to return the infant to the breast when this has ceased. As a rule, when the woman has nursed her infant for six months, and trouble arises in consequence of catamenial disturbance, it is advisable to wean the infant.

Pregnancy during Lactation.—In regard to the occurrence of pregnancy during lactation, the author cannot pretend to regard this as at all an open question. In few cases can the mother provide the infant with adequate food; in no case can she continue suckling when pregnant without endangering her own health and that of the fœtus. The worst cases of exhaustion in later pregnancy, in the author's experience, have always been cases where lactation has been maintained for a considerable period during pregnancy. There is no justification for this continuance, for, as a rule, the infant so nursed would thrive much better on an adequate substitute food, and the mother would be spared the strain of coincident lactation and pregnancy.

Defects of Breast Milk.—Human breast milk may be defective either in respect of quantity (excess or deficiency) or of chemical composition. In regard to composition, it may be said that the chief defects arise in the variations of the fat and the albuminoids. Lactose seldom varies to any great extent, and the slight variations do not appear to exert any directly prejudicial effect upon the infant. For the sake of convenience, the abnormalities of lactation may be somewhat arbitrarily classified as follows:

1. Cases where the secretion of milk is either practically absent, or is so small in amount as to be quite insufficient

to meet the needs of the infant. In these cases substitute feeding is the only course available.

2. Cases where the secretion is abundant, but very poor in both fat and proteins. In certain cases this combination of large amount with a low percentage content seems to be in the nature of a physiological adjustment of the maternal and infantile organisms, and it must not, therefore, be hastily assumed that a milk of poor quality is necessarily unsuited to the infant. Our attitude in regard to this must be determined by the condition and progress of the infant. In a great many of these cases, however, the results in the infant are far from satisfactory. As a rule, lactation of this character is generally found in weak, delicate women, and it may also be a prominent factor in the case that, even if the infant is progressing to some extent, the stress of lactation is obviously making great inroads on the strength of the mother, so that on her account nursing has to be terminated.

3. Cases where the amount is normal or approximately normal, but in which the constitution of the milk is abnormal. This may be in (*a*) excess of both fat and proteins, (*b*) excess of fat, (*c*) excess of proteins, (*d*) deficiency of both fat and proteins, (*e*) deficiency of fat, (*f*) deficiency of proteins.

Clinical Phases.—In reference to the clinical aspect of breast-feeding, three broad classes of abnormality are met with: those in which it is obvious, from the condition of the mother and the character of the milk, that she cannot supply her infant with the requisite food; those in which the milk is defective, but may with great care, possibly, though by no means certainly, be rendered adequate for the infant; and those in which the defect is so clearly due to some error of habit or diet that the due regulation and correction of these factors may be usually expected to prove completely successful.

In this matter nothing can replace clinical experience, but it is essential to success that the many factors of the subject be duly considered and estimated in their right proportion. It is illogical to deduce from the general principle that human milk is the standard food for the infant that the milk of an individual mother is the ideal food for her infant. Among the women of the wealthy classes it is comparatively rare to find a mother able to nurse her infant, however willing, and, indeed, in some cases anxious, she may be to do so. The whole life of these women is, as a rule, antagonistic to the normal functions of the mammary gland. When, therefore, there is no reasonable probability of maternal feeding being a success, it is highly prejudicial to the infant to attempt this.

Further, in those cases where there are gross defects in the milk, it must be remembered that the co-operation of the mother in regard to her diet, her environment, exercise, regularity of nursing, and many other factors, varying in each case, is of the first importance. Where there is some prospect of this co-operation being really forthcoming, then there is justification for the attempt to convert the bad food into a good one. Where there is little or no probability of this assistance on the part of the mother, it is unreasonable to make use of methods primarily based on such assistance.

On the other hand, given a willing and intelligent mother, anxious to nurse her infant, prepared to observe the necessary rules and restrictions, and where the defect is one of relative constitution as opposed to absolute inadequacy of the milk supplied by her, then the attempt to improve the composition of the milk is one likely to succeed and to be attended with the best results to the infant.

The principles which must guide us in altering the character of the milk so as to suit the infant's require-

ments need to be considered in some detail. The lactose and the salts are fairly constant factors in poor and rich milks alike, the proportionate amounts present are approximately the same; what variations are to be found cannot, in the present state of our knowledge, be definitely attributed to any one factor in diet or habit.

The Varying Elements of Milk.—The constituent elements—fat and protein—vary to a very great extent, and are largely influenced by the condition of life of the nursing woman. Hence, by regulating these conditions it is possible to modify the proportions of these bodies present. Certain clinical facts here are of importance, but, as they are generalizations from many observations, they must not be accepted as necessarily applicable without qualification to any individual case.

The fat in human milk is present in some sort of proportion to the amount of nitrogenous material and fat present in the diet of the woman. The fat apparently acts as a protein-sparer, while the protein probably acts more directly in relation to the metabolism of the mammary gland. Whatever may be the reason, a protein food, such as meat, is much more likely to increase the fat in the milk than a diet containing fat and little protein. In regard to the protein constituents, they are rarely deficient in amount unless the milk is a very dilute one, due either to irregular nursing or to inadequacy of the mammary gland. Excess is the general defect found in respect of protein, and to correct this excess nothing is so important as systematic daily exercise in the shape of walking, combined with careful attention to the general health and regulation of the diet.

A general poorness in the total solids of the milk may be due to the fact that the intervals of nursing are too prolonged; this always tends to increase the percentage of water at the expense of the other constituents. Hence,

when the analysis shows the milk to be of such a character, the nursing of the infant should be at shorter intervals. The diet should be carefully attended to, so that the mother receives a full supply of nutritious material in an easily assimilable form, and, in order to secure the restoration of the disturbed metabolic equilibrium, rest in bed should be ordered. It may be well to restrict the liquid portion of the diet within reasonable limits, but it is doubtful whether a moderate amount of liquid plays any part in the amount of water present in the milk, provided the diet in other respects contains the necessary proximate principles The balance of water in the tissues is adjusted by renal action. As has already been pointed out, in these cases of poverty of the milk the condition of the mother must always receive adequate consideration; if she is suffering in health or losing weight, it becomes necessary to terminate the lactation and to resort to substitute feeding.

Emotional Disturbance.—It must also be remembered that disturbances of lactation are by no means always due to errors of diet, or too much or too little exercise. Perhaps the most frequent instances of seriously disturbed lactation are to be found in highly nervous women. Emotional disturbances in this type of woman produce profound alterations in the composition of milk, while other factors, such as illness, the occurrence of the catamenia or of pregnancy, are frequently responsible for alterations in the milk.

As so much depends on the nursing mother, the attempt to regulate the character of her milk is one requiring in some cases a great deal of patience. Failures occur which are sometimes extremely disappointing to the physician. Yet in many cases the results are extremely satisfactory. The following cases have been selected to illustrate some of the main features of management and treatment:

Illustrative Cases.

CASE I. : *Disordered Lactation due to Errors of Diet and Habits.* —M. M., aged thirteen weeks The infant had been well during the whole of the first month. During the second month at intervals it had suffered a good deal from flatulent indigestion, attended with greenish motions. When the infant was seen, it had been suffering severely from gastric and intestinal disturbance, and was evidently in great pain. Sour vomiting of small amounts occurred persistently. The motions were very offensive, grass green in colour, and contained large curds.

The history of the lactation pointed at once to the prime cause Up to the end of the second month the mother had taken care of herself, at first being at home during the lying-in, and then in the country. On her return to town she gradually took up her usual life, lunching and dining out, frequently going to the theatre, etc. It was easy to see that during the latter half of each day the feeding of the infant was very irregular, being dependent on the mother's ability to fit in the nursing with her other engagements. It was also assumed without any doubt that the nature of many of her meals was highly improper for a nursing woman, and her exercise was practically non-existent, as she invariably made use of her carriage. This mother was extremely anxious to nurse her infant, but she had not been at all adequately informed of the care she must take of herself, and was clearly quite unaware that she was responsible for her infant's sufferings.

The digestive disorder was treated, and the infant was placed for the time being on substitute feeding. A specimen of the mother's milk was taken for analysis. The breasts were emptied by the breast-pump every three hours, and the mother gave up all her social engagements, and was placed upon a simple diet. In accordance with instructions, she also took walking exercise daily, one and a half miles in the morning and the same distance in the afternoon. At the end of a week the milk had much improved, and at the end of ten days was in a condition apparently fit for the infant. The substitute feeding was then given up, and the infant was returned to the breast ; the nursing was carried out with great care and at regular intervals, and the infant did well. The figures show the condition of the milk (I.) at the time of the illness, and (II.) after ten days' regulation of the diet, etc., as described above :

	I. Per Cent.	II. Per Cent.
Fat	1·25	3·57
Lactose	7·00	6·35
Proteins	3·95	1·87

The above case illustrates the satisfactory results that can be obtained with the co-operation of a mother willing to carry out the instructions to the best of her ability. The next case presents other features.

CASE II.—The infant was under the care of the author from its birth. During the first three months its progress was very satisfactory, save for some temporary disturbances caused by the infant taking the milk too rapidly from the breast. When this was corrected the progress was uninterrupted.

For the period of three months the mother was resting. At the end of this she returned to town. Being of an intellectual and highly excitable temperament, she took a great and active interest in many affairs. She then altogether overtaxed herself, and six weeks after returning to town took to her bed in a state of nervous prostration, which had been suddenly intensified by the death of a relative. This alternation of apparent health and nervous collapse had already occurred on more than one occasion prior to the birth of the infant. The effect of her condition on lactation was extremely prejudicial.

The details of the case need not be stated in full, but the facts concerned with the character of her milk are interesting, as they clearly illustrate the alterations caused by emotional disturbance. The figures below show the composition of the mother's milk at a time when she was well. The analyses were made as a matter of precaution I. represents the composition of the milk at the ninth day of the puerperium ; II. the composition at the end of the third month :

	I. Per Cent.	II. Per Cent.
Fat	3·12	3·87
Lactose	6·21	6·49
Proteins	1·34	1·28

On the first occasion of disturbance the infant was in great pain, and the symptoms of intestinal indigestion were severe, the gastric symptoms not being very marked. The mother was in a highly excited condition, lamenting that she was injuring her infant, and complaining of many disappointments as a result of her collapse. The analysis of her milk showed the following constitution, which was in marked contrast to those above recorded :

	Per Cent.
Fat	2·21
Lactose	6·31
Proteins	3·56

Substitute feeding was undertaken ; the mother was given a sedative to induce sleep ; her general condition was attended to, and the breasts were regularly exhausted at the usual intervals. At the end of a fortnight she had completely recovered, and her milk on analysis showed the following composition :

	Per Cent.
Fat - - - -	3·45
Lactose - - - -	6·40
Proteins - -	1·35

The infant was then returned to the breast, and did well. Three weeks later the mother again broke down suddenly, and with symptoms similar to those already described. On analysis her milk proved to be composed of—

	Per Cent.
Fat - - - -	1·25
Lactose - - - -	5·00
Proteins - - - -	4·10

The condition of the infant was extremely critical for some days : at first from convulsions, which did not yield readily to treatment, and from severe gastric and intestinal disorder ; and finally from exhaustion and collapse. After four days, in which its condition gave rise to great anxiety, the infant showed signs of recovery, and then gradually became quite restored to health. The composition of its substitute food was—

	Per Cent.
Fat - - - -	3·50
Lactose - - - -	6·00
Proteins - - - -	1·25
Alkalinity - - -	5·00

Heat at 150° F. ; seven feeds, each containing 5 ounces.

Maternal nursing was now considered to be far too dangerous to the infant, and lactation was suppressed.

This case is instructive in showing the existence of neurosis as a contra-indication to maternal nursing. An attempt was made to maintain maternal nursing when it ought to have been abandoned, on the occasion of the first failure. Being acquainted with the nervous temperament of the mother and all the facts of the case, it would have been much better if the author had adequately realized the meaning of these facts and forthwith weaned the infant. His failure to do so resulted in the life of the

infant being seriously imperilled five weeks later. Yet cases of this kind are quite commonly treated as if the condition of the infant were due to faults of its digestion rather than of its food. In consequence, the infant is dosed with grey powder, castor-oil, and all sorts of expedients are resorted to, while the prime source of the disorder remains untouched.

These cases of disordered lactation arising from emotional disturbance in neurotic women are, in the author's experience, extremely unfavourable; they react to the regulation of habit and diet much less satisfactorily than do those cases where excess of rich food and absence of exercise are the cause of the disorder. Hence, there should be no undue delay in determining the course to be taken. If serious disturbance arises from nervous causes in circumstances which indicate that it is likely to recur, substitute feeding is by far the safest course to adopt. One important qualification, however, must here be made. In some cases, excessive emotional excitement may be manifested by a mother without affecting her milk to any serious extent. These women are of a different type. They are vigorous and passionate, but not neurotic. An analysis of the milk is the important point in determining the nature of the case. When a sudden and prejudicial alteration occurs in conjunction with nervous symptoms, there should be no hesitation in terminating lactation.

The next case affords an illustration of one of the unavoidable dangers of maternal nursing:

CASE III.—An infant, four months old. Maternal nursing had been carried out with satisfactory results, and the infant had regularly gained in weight. At this time the mother was severely poisoned, in all probability by some food. She definitely attributed it to a certain meal, but no satisfactory evidence on this point could be obtained.

About an hour and a half after this meal, though feeling indisposed, she suckled her infant. Soon afterwards she was attacked with violent diarrhœa. The mother was in a critical condition for some days, and the illness was complicated by the development of colitis. Fortunately

for the infant, the mother was too ill, at the time the next feed was due, to think of nursing it. Within a few hours of the single feed (after the mother's poisoning) the infant developed the most acute symptoms of gastritis and enteritis. Vomiting and diarrhœa set in, and threatened to be almost continuous. In the space of twenty-four hours the infant seemed to be almost moribund. The stomach and the colon were irrigated, brandy was freely supplied, and the infant was kept warm by hot-water bottles packed around it. It was given a solution of 10 per cent. lactose—3 ounces every hour—which it took greedily. Two teaspoonfuls of castor-oil were given after vomiting had ceased for three hours, and this was retained. After complete deprivation of milk for twelve hours, it was given a substitute food as follows :

	Per Cent.
Fat - - - -	1·00
Lactose - - - -	5·00
Whey proteins - -	0·50
Caseinogen - - -	0·10
Alkalinity - - -	10·00

Unheated ; twenty feeds ; each of 1 ounce.

(The term 'unheated' is, of course, a laboratory instruction. Each feed was raised to 100° F. immediately before being given to the infant.)

The feeds were ordered to be given every hour. Though the infant was very weak, and had lost 2 pounds in weight, it soon began to show signs of improvement, and on the fifth day it was making very distinct progress.

The illness of the mother precluded any attempt at the renewal of maternal nursing. The infant did well on the substitute food, which was gradually enriched. At the end of three weeks from the attack it was digesting well a food according to the following prescription :

	Per Cent.
℞ Fat - - - -	3·75
Lactose - - - -	6·50
Proteins - - - -	1·50
Alkalinity - - -	5·00

Unheated ; seven feeds, each of $5\frac{1}{4}$ ounces.

As is well known, the mammary gland during lactation actively excretes many forms of poisonous products. This, which accounted for the perilous condition of the infant, was taken advantage of, and in order to secure, as far as possible, the rapid elimination of the poison from the

mother, the breasts were regularly pumped. In a few days, however, the secretion of milk quite ceased.

Mixed Feeding.—In certain cases, where the mother is unable to sufficiently supply her infant, the method of mixed feeding is frequently resorted to. It not uncommonly happens that at the beginning of lactation the mother is unable to provide all the food required by the infant. In these cases the occasional feeding of the infant by substitution is of the greatest value, since it provides the infant with what it requires and gives the mother time for the full development of lactation. But in those cases in which, when lactation has previously been sufficient and has adequately met the requirements of the infant, the milk-supply begins to fail, the advisability of mixed feeding is, in the author's opinion, much open to question.

The failure of the mammary gland must be regarded as an indication of exhaustion. In the interests of the mother it is unfair to advise her to continue nursing when evidence of the stress is present; in the interests of the infant it is unwise to continue to rely upon the mother when her ability to nurse is demonstrably failing. With the qualification above referred to, the author has seldom found mixed feeding to be of advantage to either mother or infant. It is undoubtedly the case that the deficiencies of the mother can to some extent be met by the substitute food; but it is far from clear that it is to the advantage of the mother that lactation should be allowed to continue when it is demonstrated that the provision of the food meeting her infant's requirements is beyond her powers. In these cases the health and strength of the mother are important factors which need the fullest consideration. Failing lactation is, as a rule, an indication that the task is too much for the woman; and it must be remembered that the function is no light one. A woman in indifferent health cannot produce a

good milk. In addition to these considerations, there is the practical objection to mixed feeding that the infant is receiving two foods. Of one the composition is, or should be, known; of the other the composition is unknown, for the quality of the milk when lactation is failing greatly varies.

Weaning.—When weaning of the infant has to be undertaken either at the normal period or earlier, it is important that this should be carried out without distress to either mother or infant. In all cases where it is practicable, it should be made a gradual process. The rules guiding us in this matter vary according to the nature of the case. Where the infant has been fed by its mother for the normal period, and the termination of lactation becomes necessary for physiological reasons, the condition of the infant should be carefully inquired into. If it has gained weight regularly, and its development has been continuously satisfactory, the maternal milk should be our guide as to the composition of the food of the infant. Before undertaking the substitute feeding, the mother's milk should be analyzed. The milk mixture should then be graduated in accordance with the results of this analysis. It is well, however, at first to slightly diminish the albuminoid percentage. This is by far the commonest cause of digestive disturbance, and until the infant is satisfactorily established on its new food it is better to keep the amount of albuminoids somewhat below normal. As soon as it is clear that the infant can digest the food without difficulty, this can be gradually raised. When the age of the infant indicates this, the milk mixture should be gradually approximated to the composition of whole cow's milk, so that in due course this may be legitimately provided.

In other cases, for a variety of reasons, it becomes necessary to wean the infant long before the normal term of lactation. As a precautionary measure, it is always

advisable to obtain and analyze a specimen of the mother's milk when the infant is thriving, and when, probably, there is no question of weaning. Should the suppression of lactation become necessary at a later period, the knowledge derived from this examination is of great assistance in indicating the precise quality of the substitute food to be prescribed. Where the termination of maternal nursing is not urgently called for, the lactation should not be suppressed till it has been ascertained clinically that the substitute food is suited to the digestion of the infant and meets all the requirements of nutrition. This delay provides the opportunity for further modifications and adjustments until the necessities of the case are duly appreciated and provided for.

In reference to those cases where the function of the mammary glands is not performed at the outset, or fails suddenly, or where for other reasons substitute feeding becomes necessary, it need only be said that the factors of general nutrition should be, for the moment, entirely subordinated to the immediate object of establishing the infant on a graduated milk without resulting digestive disturbance. As soon as this has been accomplished, the enrichment of the diet so as to provide a food meeting the full requirements can be gradually carried out.

CHAPTER III

COW'S MILK

WHEN for any reason maternal nursing is inadvisable or impossible, the infant has to be fed on milk derived from another woman or from some animal. Of animal milks, there is only one, that from the cow, which can be readily obtained in sufficiently large quantities at a moderate cost. This milk, as the basis of the substitute food, therefore needs detailed consideration.

Physical Characters.—Cow's milk is an aqueous solution of lactose, albumin, and salts, holding in suspension globules of fat and containing caseinogen, combined with certain of the salts, in a state of semi-solution.

Its reaction when freshly drawn is amphoteric to litmus paper; but cow's milk at the time of milking is invariably found to be acid in reaction when the methods of examination are sufficiently accurate. The acidity is usually equal to a lactic acid percentage between 0·14 and 0·18.

The specific gravity of the mixed milk of a herd is usually between the limits of 1030 and 1034, the average specific gravity being 1032. This factor varies according to the amount of the total solids, the causes of the variations being of the same character as those described in reference to the human milk.

Average Composition.—Richmond,[1] on the basis of

[1] 'Dairy Chemistry,' p. 120. London, 1899.

about 200,000 analyses, formulated the average chemical composition of the milk as follows:

	Per Cent.
Fat - - - -	3·90
Lactose - - - -	4·75
Caseinogen - - -	3·00
Albumin - - - -	0·40
Ash - - - -	0·75
Water - - - -	87·10

These figures may, from the large number of analyses, be regarded as representative of the typical composition of cow's milk when the cows are fed by the ordinary methods, and where numbers of cows are included, so that the amount of total solids is low. Where the cows are selected and their diet and environment are carefully designed to produce a milk of fine quality, the fat and proteins stand at a higher figure. Rotch has investigated the character of the milks of various cows with special reference to their fitness for infant feeding, and he selected the following breeds as being most suitable.

Differences of Composition in Various Breeds.—The **Shorthorn** has constitutional vigour, a sound digestion, with great capacity for food, is of a placid temperament, and her milk is rich in total solids. The average composition of her milk is—

	Per Cent.
Fat - - - -	4·04
Lactose - - - -	4·34
Albuminoids - - -	4·17
Mineral matter - -	0·73
Water - - - -	86·72

The **Devon** is of a similar character, the total amount of milk provided being, as a rule, rather less. Her milk is of the following approximate constitution:

	Per Cent.
Fat - - - -	4·09
Lactose - - - -	4·32
Albuminoids - - -	4·04
Mineral matter - -	0·76
Water - - - -	86·79

The **Ayrshire** breed is strong and vigorous, but these cows are more susceptible to their surroundings by reason of their temperament being more nervous. Their milk is represented by the analysis below:

	Per Cent.
Fat - - - -	3·89
Lactose - - - -	4·41
Albuminoids - - -	4·01
Mineral matter - -	0·73
Water - - - -	86·96

The **Holstein-Friesian** provides a very delicate milk, and in America this breed appears to be largely used for laboratory purposes. The ordinary dairyman, however, does not as a rule regard her with favour, since, though her yield of milk is exceptionally large, the total solids are low in amount. Moreover, where whole milk is also required she is distinctly unsuitable. The amount of fat is less than the minimum for milk on sale permitted by Government regulations (3 per cent.). The constitution of this milk is—

	Per Cent.
Fat - - - -	2·88
Lactose - - - -	4·33
Albuminoids - - -	3·99
Mineral matter - -	0·74
Water - - - -	88·06

Several other varieties may be used, but the above specimens indicate the general characteristics of the cows suitable for the purposes of infant feeding.

General experience appears to be very distinctly in favour of the shorthorn cow as the most favourable for the laboratory in this country. For strength, vigour and general reliability she holds the first place. It would be a great economy if the Jersey and Guernsey cows could be used, as they yield a much higher proportion of fat. But, unfortunately, the emulsion is very imperfect, and the fat globules are so large as to render the milk quite unsuitable for the purposes of infant feeding.

Variations in Cow's Milk.—In relation to this aspect of the subject, it must be remembered that cow's milk, like

human milk, is liable to variations from day to day, these variations being dependent on changes of diet, environment, etc. Further, various other factors are known to be definitely associated with changes in the quality and character of the milk.

In the following table, quoted from Richmond,[1] are shown the variations in the total solids, fat, and solids-not-fat, as determined by Vieth from analysis of the milk of the cows kept at the Horsham Farm of the Aylesbury Dairy Company:

TABLE SHOWING SOLIDS IN MILK OF COWS OF DIFFERENT BREEDS (VIETH).

Breed.	Total Solids.			Fat.			Solids-not-Fat.		
	Max.	Min.	Aver.	Max.	Min.	Aver	Max.	Min.	Aver.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Dairy shorthorn	18·7	10·2	12·90	10·2	1·3	4·03	10·6	7·6	8·87
Pedigree shorthorn - -	16·8	10·5	12·86	7·5	1·9	4·03	9·8	7·6	8·83
Jersey - -	19·9	11·0	14·89	9·8	2·0	5·66	10·4	8·1	9·23
Kerry - -	18·6	10·6	13·70	10·5	1·8	4·72	10·6	4·9	8·98
Red-polled -	16·2	9·7	13·22	6·6	2·5	4·34	10·2	7·1	8·88
Sussex - -	17·4	11·5	14·18	7·6	2·9	4·87	10·3	8·4	9·31
Montgomery -	16·1	10·2	12·61	6·5	1·4	3·59	10·0	7·9	9·02
Welsh - -	17·6	11·9	14·15	8·3	3·0	4·91	9·6	8·9	9·24

Nervous Influences.—The cow is a nervous animal, peculiarly susceptible to environment. Emotional disturbance in the human mother is probably the most frequent cause of pathological changes in her milk, and this fact has already been illustrated. It is interesting to note that observations of a very different character seem to show that disturbances of a like nature occurring in the cow produce similar results. When cows are exhibited at agricultural shows, the proportion of the total solids of their milk is almost invariably seriously altered. Richmond

[1] 'Dairy Chemistry.' London, 1899.

states that the low fats recorded in a certain series were due mostly, if not entirely, to this cause. Dyer has recorded the case of a cow which, during exhibition, secreted a milk containing but 1·85 per cent. of fat. On the day after the exhibition her milk contained 3·64 per cent. of fat. The environment of milch cows is therefore an important matter, and requires special recognition in reference to infant feeding. Variations within moderate limits occur in the same cow from day to day, so that for all purposes it is much better that the milk should be derived from a number of cows rather than from one.

Seasonal Variations.—Definite alterations in the character of cow's milk occur according to the season. During November, December, and January the milk is rich in fat and in the other solid constituents. In the months of February, March, and April the milk is less rich in fat, but the other solids are not appreciably diminished. From May to August the fat is smaller in amount, and in July and August the other solids are less in amount than usual. During September and October the milk gradually increases in richness to the standard of the winter months.

Richmond has published a table graphically illustrating these seasonal changes :

SEASONAL VARIATIONS IN COW'S MILK.

Month.	Specific Gravity.	Total Solids.	Fat.	Solids-not-Fat.
		Per Cent.	Per Cent.	Per Cent.
January - -	1·0322	12·88	4·02	8·86
February - -	1·0322	12·78	3·93	8·85
March - -	1·0322	12·71	3·88	8·83
April - -	1·0322	12·66	3·84	8·82
May - -	1·0323	12·66	3·82	8·84
June - -	1·0322	12·59	3·79	8·80
July - -	1·0317	12·66	3·93	8·73
August - -	1·0316	12·73	4·02	8·71
September - -	1·0319	12·92	4·12	8·80
October - -	1·0322	13·13	4·21	8·92
November - -	1·0322	13·19	4·30	8·89
December - -	1·0322	13·04	4·16	8·88

Daily Variation.—It is well known by all practical dairymen that the evening milk is richer than that of the morning, and for this reason, in connection with laboratory feeding, the morning milk is used for the purpose of preparing modified milk mixtures, while the evening milk is reserved to supply the demands for whole milk. The evening milk is richer in all the solids. This is well illustrated in the table appended:

COMPOSITION OF MORNING AND EVENING MILK.

Month.	Morning Milk.				Evening Milk.			
	Specific Gravity.	Total Solids.	Fat.	Solids-not-Fat.	Specific Gravity.	Total Solids.	Fat.	Solids-not-Fat.
January -	1·0327	12·76	3·71	9·05	1·0324	13·16	4·10	9·06
February -	1·0327	12·63	3·61	9·02	1·0324	13·02	4·00	9·02
March -	1·0327	12·63	3·61	9·02	1·0323	12·96	3·95	9·01
April -	1·0327	12·58	3·56	9·02	1·0325	12·93	3·90	9·03
May -	1·0328	12·42	3·40	9·02	1·0323	12·76	3·79	8·97
June -	1·0323	12·31	3·42	8·89	1·0318	12·55	3·72	8·83
July -	1·0316	12·24	3·50	8·74	1·0312	12·50	3·80	8·70
August -	1·0315	12·40	3·65	8·75	1·0313	12·69	3·96	8·73
September	1·0321	12·61	3·71	8·90	1·0318	13·07	4·15	8·92
October -	1·0328	12·83	3·75	9·08	1·0324	13·23	4·17	9·06
November	1·0329	12·89	3·78	9·11	1·0325	13·27	4.17	9·10
December	1·0327	12·87	3·80	9·07	1·0324	13·24	4·17	9·07
Average -	1·0325	12·60	3·63	8·97	1·0321	12 95	3·99	8·96

This variation is not so much due to the precise time of milking as to the fact that the interval between the morning and evening milking is, as a rule, of less duration than that between the evening and morning milking. The shorter the interval, the greater the proportion of total solids. This particularly applies to the proportion of fat.

Period of Milking.—Moreover, the character of cow's milk, as of human, materially depends upon whether the milk withdrawn is from a full mammary gland or from one nearly empty. Reisch and Peligot analyzed the

first, second, and third portions of the milk of the ass and of the cow. They found that at the end of milking there was an increase in the total solids, and that this was due to an increase to some extent in the proteins, but chiefly in the fat. Harrington's analyses of the 'fore milk,' 'middle milk,' and 'strippings' illustrate the same fact :

	Fat.	Total Solids.	Water.	Mineral Matter.
'Fore milk' -	3·88	13·34	86·66	0·85
'Middle milk' -	6·74	15·40	84·60	0·31
'Strippings' -	8·12	17·13	82·87	0·82

The milk drawn first from the udder is thus demonstrably deficient in fat and total solids when compared with that last drawn. Boussingault, dividing the period of milking into arbitrary portions and analyzing each specimen, arrived at the following figures, which clearly show the comparative richness of the later portions :

	I.	II	III.	IV.	V.	VI.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Total solids -	10·47	10·75	10·85	11·23	11·63	12·67
Fat - -	1·70	1·76	2·10	2·54	3·14	4·08
Solids-not-fat	8·77	8·99	8·75	8 69	8·49	8·59

Cow's milk is, thus, far from being a product of stable and uniform quality. Many other factors—notably, the precise character of the diet—have great influence on the character of the milk yielded by the cow. In reference to infant feeding these points are of the greatest importance. No attempt at accurate graduation of cow's milk to the needs of the infant can be successful when the prime material is an unknown quantity. In the milk laboratory the standardizing of the milk forms one of the elementary procedures, without which the results would necessarily be vitiated.

Colostrum.—Before and after parturition, *colostrum* is yielded by the cow. Its specific gravity is from 1046 to 1079, and its average composition is as follows:

	Per Cent.
Fat - - - - -	3·37
Sugar - - - -	2·48
Total albuminoids - -	20·68
Mineral matter - -	1·78
Water - - - -	71·69

Houdet analyzed the milk of the cow in relation to parturition, and the changes were found by him to be as in the following table:

	Fat.	Sugar.	Soluble Proteins.	Colloidal Proteins.	Calcium Phosphate.	Other Salts.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Six days before calving - -	0·50	2·35	0 47	17·43	0·44	0·36
Four days before calving -	3·01	3·17	0·45	12·08	0·47	0·40
Immediately after calving -	3·14	2·70	0·25	14·53	0·46	0·42

Richmond's figures illustrate the gradual transition from colostrum to normal milk:

CHANGE OF COLOSTRUM TO NORMAL MILK.

	Fat.	Sugar.	Soluble Proteins.	Colloidal Proteins.	Calcium Phosphate	Other Salts.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Immediately after calving - -	5·69	3·30	0·51	14·05	0·51	0·54
1 day after calving	4·48	4·05	0·93	5·21	0·43	0·43
2 days " "	5·70	4·32	1·98	3·52	0·43	0·45
3 " " "	7·40	4·26	2·41	3·45	0·43	0·40
4 " " "	3·20	4·44	0·56	5·20	0·40	0·30
6 " " "	4·20	4·64	1·19	4·02	0·38	0·29
8 " " "	4·10	4·96	0·48	3·56	0·40	0·30
14 " " "	3·85	5·03	0·58	3·74	0·35	0·36

In connection with these figures, it is scarcely necessary to point out that colostrum milk is quite unsuitable for use as milk for any purpose. In relation to infant feeding, no milk should be used from a cow that has recently calved until careful observations have shown that the colostrum element has completely disappeared.

Milk of other Animals.—Reference may here be made to the milks of certain other animals, as these have occasionally been used for infant feeding. The figures for the ass, goat, and mare are, approximately, as follows:

	Ass.	Goat.	Mare.
	Per Cent.	Per Cent.	Per Cent.
Fat	1·26	4·63	1·17
Lactose	6·50	4·22	6·89
Proteins	1·64	4·35	1·84
Mineral matter	0·48	0·76	0·30
Water	90·12	86·04	89·80
	100·00	100·00	100·00

Of these, ass's milk has been, to some extent, made use of for delicate infants. With our present knowledge, it is quite unnecessary, and, indeed, altogether inadvisable, to make use of the milk of any of these animals. If a milk of a composition similar to that of ass's milk be desired, it is quite easy to obtain one from the laboratory so that the precise composition of the mixture is known, and this can be further exactly modified and increased or decreased in strength, according to the requirements of the case. It is therefore unnecessary to discuss these milks.

Differences between Human and Cow's Milk.—The constitution of cow's milk, in regard to the relative proportion of the constituents, is widely different from that of human milk, and it is necessary that the nature and extent of the differences should be adequately appreciated. The reaction of cow's milk is invariably acid, and in order to counteract this some alkali must be used. The necessary alkalinity may be obtained by means

of lime-water, bicarbonate of soda, or phosphate of soda. The mineral salts are, however, already in excess in cow's milk, so that the addition of these salts can scarcely be regarded as beneficial, though, when administered in minute quantities, the author is not acquainted with any harmful results following their use.

Correction of Acidity.—Lime-water answers the purpose extremely well. Harrington experimented on cow's milk twenty-four hours old to determine the amount of lime-water necessary to counteract the acidity without causing excess of alkalinity. His results were as follows :

Amount of Lime-water in Mixture.	Reaction.
25 per cent. - - -	Strongly alkaline.
12·5 per cent. - - -	Still strongly alkaline.
6·25 per cent. - - -	Slightly alkaline, corresponding to human milk.

This last percentage was, therefore, proved to be the amount necessary to produce an alkaline reaction of the requisite degree. At the same time, when cow's milk is collected under the special precautions to be described later, the acidity of the milk is much less. It has already been pointed out that the reaction, on leaving the udder, is amphoteric, and that marked acidity only develops when the milk is allowed to remain under comparatively unhygienic conditions. At a temperature of 65° F. the acidity develops with comparative rapidity ; at 40° F. the development is nil. The acidity arising during incubation represents the degree of bacteriological development. In milks modified at the laboratory, 5 per cent. of lime-water is usually quite sufficient, and a greater percentage than this is never called for, unless the condition of the infant constitutes an indication for increased alkalinity.

Special precautions are called for to ensure that the hydrate of calcium employed in the preparation of lime-water is pure. The commercial hydrate generally contains appreciable quantities of calcium chloride. Inasmuch as

the hydrate is only very slightly soluble while the chloride is exceedingly soluble, many preparations of lime-water are acid instead of alkaline. At the Infants Hospital milk laboratory the lime-water is made with pure calcium hydrate prepared from marble.

Specific Factors requiring Adjustment.—The amount of fat present in human and in cow's milk is, practically speaking, the same, and we may usually regard this as 4 per cent. But, in the graduation of the protein content by dilution, the fat percentage is inevitably seriously diminished, and, as fat is of extreme importance in regard to general nutrition, the method of modification adopted must be such as to allow for the supply of the full amount of fat required by the infant.

The lactose in cow's milk is much less than that in human milk, and, for the same reason, the amount becomes still further reduced when the milk is diluted. This fact calls for the addition of the requisite amount. Unfortunately, the generic term 'sugar' has led to the systematic use of bodies never found either in human milk or in that of any animal. Cane-sugar, maltose, dextrose, etc., have physiological and chemical reactions of their own, very definitely distinguished from those of lactose.

The table shows the relative proportions of the constituents of human milk and of cow's milk.

	Human Milk.	Cow's Milk.
	Per Cent.	Per Cent.
Fat	4·00	4·00
Lactose	7·00	4·50
Whey-proteins	1·00	1·00
Caseinogen	0·50	2·75
Mineral salts	0·25	0·75
Water	87·25	87·00

Cow's milk thus contains twice as much nitrogenous matter as human milk. But by far the greatest amount of this is present in the form of caseinogen, while the

proportions of lactalbumin and the extractives are relatively low. The average amount of caseinogen is about 2·75 per cent., whereas human milk contains considerably less than 1 per cent., the average amount being about 0·50 per cent. In human milk the lactalbumin and the extractives predominate. On the addition of acids to cow's milk, large bulky curds are formed. This coagulation, in the case of human milk, is very slightly marked, and the curd is small and flocculent. With rennin the same contrast is observed, the curd of cow's milk being dense and tough, that of human milk light and granular.

The adjustment of the albuminoid content therefore constitutes the crux of the problem. Not only is the albuminoid content of cow's milk far greater than that of human milk, but the relative proportions of the albuminoids and nitrogenous extractives are reversed.

Character of Milk Proteins—Caseinogen.—The two chief proteins present in cow's milk are caseinogen and lactalbumin; lactoglobulin is only present in slight traces, and does not require separate consideration. Caseinogen is present in great amount, and constitutes about 75 per cent. of the total proteins. It is coagulated by the rennin ferment, and the term 'casein' is applied to this precipitated form. This coagulation is directly affected by the presence of alkaline calcium salts; in either the absence or excess of these, precipitation does not occur. It is, however, an interesting fact that, although precipitation does not occur in the absence of these calcium salts, the action of rennin produces a distinct change, so that, if the ferment is killed by heat after being allowed to act on milk, and calcium salts are then added to the milk, coagulation immediately occurs. From this it may be assumed that the change wrought by rennin is essentially the same whether the lime salts be absent or present, but that the insoluble form of the changed product only occurs as a result of its combination with calcium. It is asserted by

several observers, with considerable probability, that all the proteins of milk exist in combination with mineral salts.

Caseinogen is not coagulated by heat, but it is coagulated by acetic acid in small amount, and becomes soluble in the presence of an excess of the acid. It is precipitated from neutral solutions by the sulphates of ammonium and magnesium in saturated solution.

Lactalbumin.—Lactalbumin in its reaction is quite distinct from caseinogen. It begins to coagulate at a temperature of 161·6° F., but is not completely coagulated till the temperature reaches about 175° F. It is not coagulated either by dilute acetic acid or by rennin. Magnesium sulphate in saturated solution does not cause precipitation, though this results when ammonium sulphate is present in saturated solution. It is also precipitated by alcohol. The most rapid precipitant is Millon's reagent,[1] which is the most effective means of demonstrating the proteins contained in whey.

In the modification of cow's milk for infant feeding it is necessary that the method adopted be one allowing of the elimination of the excessive caseinogen whilst securing the presence of the whey proteins in sufficient amount.

Adjustment of Cow's Milk.—The method of eliminating the excess of caseinogen requires especial consideration. No method of mere dilution can do anything to correct this serious fault. It is, of course, possible by dilution to so reduce the amount of caseinogen present in the mixture that it is tolerated by the digestion of the infant. But this can, obviously, only be done at the expense of the general nutrition and development of the infant. By this method, the appetite is more or less assuaged while the physiological demands are totally neglected.

Chemical analysis clearly shows the differentiation

[1] Mercury is dissolved in its own weight of nitric acid; the solution is diluted with twice its volume of water; the clear liquid is decanted and forms the reagent.

between albumin and caseinogen. But it is much to be doubted whether these results may be regarded as showing the true proportion between these constituents. It has been shown that the condition in which the albuminoids exist is a very delicate one, easily susceptible of chemical changes likely to defeat the object of the analyst. And it must further be remembered that the methods of analysis, in regard to these complex organic substances, cannot be compared in exactitude and precision with the methods used for detecting the presence of, and estimating the amount of, inorganic substances—such, for instance, as arsenic.

Clinical Factors of Adjustment.—In this respect, clinical and practical evidence is of great value. As the result of considerable experience in the adjustment of the protein content to dietetic and nutritional requirements, the author is confident that the adoption of the standard of human milk which has been propounded (p. 22) will lead to satisfactory results, when the food mixtures are progressively adjusted to the needs of the individual infant.

For quite young infants—*i.e.*, for those under six weeks of age—the proportion of whey proteins to caseinogen should be as 3 to 1. From this period to three months of age the proportion may be gradually adjusted, so that at or about the age of six months, approximately, discrimination between the albuminoids becomes unnecessary. This practical experience is supported by chemical analysis, for it has been clearly shown that the proportion of caseinogen relative to lactalbumin is much increased in the later stages of human lactation.

The Nitrogenous Extractives.—When caseinogen is precipitated so as to form the insoluble casein, the fluid remaining contains the soluble proteins, lactose and the mineral salts, together with bodies such as hypoxanthin, lecithin, creatin, creatinin, cholesterin, etc. The extractives are present in much larger proportion in the early

months of human lactation. The use of whey, therefore, as the diluent, in contrast with water, is by no means confined to its effect in adjusting the albuminoids.

Influence of Extractives on Nutrition — While we cannot, at present, state with precision the exact function of these organic bodies in the milk plasma, there can be no question that they play an important rôle in the nutrition of the infant. As his cases have accumulated, the author has been much struck by the contrast between young infants fed on mixtures containing a considerable amount of whey and those fed on mixtures where the dilution has been accomplished by means of water. Taking only those cases where the infant has digested the milk-water mixture and has regularly gained weight, and eliminating all those where serious gastric or other disturbance has intervened, the contrast is still marked.

The *active* health, the excellent colour, the bright and happy condition, of the infants fed on accurately graduated mixtures containing the bodies present in the whey are most noticeable features. These characteristics of choice development are seldom seen in the infant merely supplied with the absolute essentials of physiological nutrition, but deprived of those elements necessary to perfect metabolism.

Oliver[1] has shown that, while proteins such as myosin and egg-albumin do not alter the blood-pressure or the flow of tissue-lymph, muscle extractives such as creatinin and xanthin markedly increase arterial pressure and the exudation of tissue-lymph. He concluded from a series of valuable observations—(1) that the food constituents themselves do not possess the power of starting the mechanism by which lymph is dispensed to the tissues throughout the body ; (2) that Nature, however, associates with our food-stuffs small quantities of certain very active substances which bring into play that mechanism, though

[1] *Lancet*, January 30, 1904.

these substances themselves are practically devoid of food value.

Practical Effects of Defective Composition.—The total solids of milk in all animals are relatively small, and when these are separated into their several constituents the figures appear insignificant; so that the reader unversed in the full technical details is perhaps inclined to regard elements which are present in amounts less than 0·50 per cent. as bodies almost negligible, and not at all likely to be of any real practical interest.

In the diet of the infant these small percentages are of very great importance. Any error is enormously multiplied by the fact that, in contrast with the adult, the infant's food is of precisely the same nature at each meal, except for the variations of composition necessary from time to time.

A deficiency of 1 per cent., for instance, of fat means a serious deprivation to the infant. If an infant is taking 40 ounces of a modified milk per diem, and this mixture contains less fat than it should, and the amount of fat deficient is 1 per cent. of the whole mixture, then the infant is deprived of nearly half an ounce of *pure fat* in a single day. Such a deficiency, continued over weeks and months, cannot but produce serious effects.

The same point may be well illustrated by comparing two prescriptions precisely the same, with the exception that in one the whole proteins are used, in the other the proteins are divided:

I.	Per Cent.
Fat	3·00
Lactose	6·00
Proteins	1·00
Alkalinity	5·00

II.	Per Cent.	
Fat	3·00	
Lactose	6·00	
Whey proteins	0·75	1·00
Caseinogen	0·25	
Alkalinity	5·00	

When these prescriptions are translated into actual mixtures, their difference is much more striking than their similarity, as will be seen by the subjoined figures :

	Mixture in accordance with Prescription I.	Mixture in accordance with Prescription II.
	C.C.	C.C.
Cream (32 per cent.)	112	112
Fat-free milk	249	33
Lime-water	60	60
Lactose (20% solution)	276	92
Whey	Nil	859
Distilled water	503	44
	1200	1200

The purity of the milk employed is of especial importance when whey forms a large proportion of the daily food of the infant. When deleterious materials, such as oil-cake, etc., are present in the cow's diet, the derivatives of these bodies are excreted in the milk. These remain in solution in the whey, so that an infant fed on a prescribed milk mixture prepared from impure milk of the character indicated would receive a much larger proportion of these deleterious ingredients if fed on the second mixture than if fed on the first. The same argument also applies to cases where the cows receive an undue supply of mangolds or of green food.

Having thus summarized the main factors affecting the problem of modifying cow's milk so as to meet the requirements of the human infant, it is necessary to discuss in detail the practical methods by which the adaptation is best accomplished.

CHAPTER IV

SUBSTITUTE FEEDING—PREMATURE INFANTS—THE DIET OF LATER INFANCY

Substitute Feeding.

In relation to infant feeding, it is necessary to make our terminology as exact as possible, in order that confusion of thought and expression may be avoided. The only natural method of feeding the young infant is by maternal nursing, and this method is to be preferred to any other, in favourable circumstances. Certain other methods are available, and fall into two classes—those by which the infant is supplied with milk from another woman, or from some animal, after modification to adapt it to the infant's digestion, and those by which an infant is fed on preparations artificially manufactured from milk or from other products.

There is no essential distinction to be drawn between wet-nursing and feeding by modified cow's milk ; for though maternal nursing must rightly be regarded as the only natural method, there is no justification for regarding breast-nursing by another woman as natural. It would be an assumption far from being justified by the facts that the milk of a wet-nurse necessarily meets the requirements of the infant. On the other hand, the term 'artificial' can scarcely be applied with accuracy either to wet-nursing or to those methods of modifying cow's milk which consist in providing a food as closely approximating to the natural

food and its natural conditions as our present knowledge permits. For these methods the term *substitute feeding* appears to be the most suitable. The term *artificial feeding* is here reserved for those methods of feeding where the food mixtures are derived from products artificially prepared by manufacturers. This practice is only to be justified on grounds of temporary emergency, where neither natural nursing nor any form of substitute feeding is available. It is only in very exceptional circumstances that such cases arise, and therefore, in general, artificial feeding may be regarded as synonymous with improper feeding.

Wet-Nursing. — In reference to the employment of a wet-nurse, it may be said that this expedient is seldom, if ever, justified where the best methods of substitute feeding are available. The practical difficulties associated with the employment of a foster-mother are unquestionably very great. Her health must be thoroughly sound. Every writer on the subject points out, especially, that she must be free from syphilis; but none has ever succeeded in showing how this disease may with certainty be excluded. In many cases the signs of syphilis may be clearly marked, but in women still capable of infecting the infant they nurse there may be no signs definitely pointing to syphilis, and were one to exclude every wet-nurse unless it could be definitely proved that the woman was not syphilitic, the number of wet-nurses available would be extremely small. This consideration, having regard to the class from which wet-nurses are drawn in this country, is of critical importance.

Further, the use of a wet-nurse is an expedient which may prove to be attended with excellent results, the milk meeting the infant's requirements, with the consequence that its gain in weight and its general condition are quite satisfactory. In such a case it is clear that the milk provided by the nurse is of a quality required by the infant.

But in the selection of a wet-nurse it is practically quite impossible to ensure this, and hence this method must be regarded as empirical and haphazard in its essential features. The possibilities of altering the character of woman's milk are extremely limited when compared with the opportunities of accurately graduating cow's milk.

In connection with wet-nursing, the domestic difficulties are often very great, and it is by no means infrequent to find the infant's life suddenly imperilled by reason of the nurse's misconduct.

In the past, when the methods of modifying milk were arbitrary and the food mixtures were far from being in harmony with physiological requirements, there can be no doubt that the services of wet-nurses were often invaluable; for in many cases infants were quite unable to digest cow's milk so inadequately modified, and the use of a wet-nurse was justified by this fact.

With our present knowledge the position is altogether altered. In accurate adjustment of food to meet the infant's need, in facility and precision, the advantages are now all on the side of modified cow's milk, and only the necessary knowledge and appreciation of the various factors of the individual case are required to enable us to prescribe a mixture based on the standard of human milk and graduated to meet the precise needs and idiosyncrasies of the particular individual.

It need hardly be said that, with arbitrary and unscientific methods of milk modification, frequent failures must occur, and the present tendency to make use of a wet-nurse in cases of difficulty is largely due to the use of these methods.

It is still, unfortunately, true that many authorities advocate these traditional methods. The idiosyncrasies of infants vary so greatly that almost any method, however inadequate or unscientific, must succeed, to some extent, in a certain number of cases, and thus provide results

which, on superficial examination, appear to afford some justification for unscientific practices. The failures do not receive the same degree of attention, and are generally ascribed to the condition of the infant.

The didactic methods of adapting cow's milk to infant feeding are almost innumerable. While they are all more or less based on the different constitution of human and cow's milk, these differences are necessarily very incompletely allowed for, and the important factor of exact adaptation to the individual infant is almost wholly absent.

To Rotch of Boston we owe the institution of a method enabling the physician to precisely adapt the food of the infant to its peculiar requirements, and at the same time affording him every opportunity of judging the part played by the various constituents of the diet.

Recognizing the essentially unscientific character of the traditional methods, he devoted his attention to the real factors of the problem which had for so long been neglected, with the object of arriving at a system by which a milk mixture could be prepared, in the constitution of which the comparative importance of every essential element received due recognition.

The great and lasting value of his work lies in the abolition of all didactic rules and in the provision of an instrument combining clinical elasticity with scientific precision. By the method which he devised, any desired milk mixture can be prescribed so as to contain the various constituents in any proportion required. If the prescribed mixture prove in any way unsatisfactory, it can be adjusted with the greatest delicacy and precision to the needs of the infant. Rotch dealt systematically with every phase of the problem, and the first establishment of milk laboratories was due entirely to his efforts.

The arrangements for providing the patients of the Infants Hospital with a substitute food afford a complete practical illustration of the technical details involved in

the production and modification of milk for infants, and the following account gives the history of the milk from the farm to the ward.

The Farm.—The technical management of the farm (Combe Bank Farm, Sevenoaks) is governed by a Board of Control, consisting of the Treasurer of The Infants Hospital, the Senior Physician to the Hospital, the Veterinary Surgeon to the farm, and the Medical Officer to the farm employees. The Board meets once a month, when full and detailed reports of the farm are considered. The daily reports from the Research Laboratory of the Hospital constitute the basis of the technical control in regard to the purity and quality of the milk.

Milking Sheds.—The milking sheds (Fig. 2) have been specially designed so as to provide—(1) thorough ventilation, (2) ample light, (3) facilities for rapid and efficient cleansing, (4) safe drainage. The ventilation is effected by doors and windows, assisted by a 'false roof' running the whole length of the sheds. The cows are thus protected from the weather, while there is free egress for vitiated or heated air along the whole shed. The sheds are fitted with hydrants, and are thoroughly flushed out twice a day immediately before milking, so that the floor and stalls are wet when the cows enter. By this means the raising of dust during the process of milking is reduced to a *minimum.* The drainage system is so arranged that all material from the shed is flushed into an external culvert, so that in the event of any obstruction occurring in the drains the sheds would not be disturbed. These sheds are used solely for the purpose of milking, and the cows only occupy them for a short period twice a day; the rest of the day they spend elsewhere. In summer they are in the meadows, while in winter they are cared for in specially constructed winter-quarters (Fig. 3).

Winter Quarters.—The winter quarters may be de-

PLATE I.

Fig. 2.—One of the Milking-Sheds.

Fig. 3.—Interior of Winter Quarters.

To face page 80.

scribed as large yards roughly covered in to protect the animals from the inclemency of the elements. The roof is high, but is not solid; between each plank is a break of about ¼ inch. This allows for extremely free ventilation, while the opening is not wide enough to allow of rain entering. The sides are so arranged that, in the coldest weather, they can be completely closed, while at other times they may be widely opened.

Selection of Cows.—The cows are specially chosen, so as to yield a quality of milk most suited to the special requirements of infants. Jerseys, Guernseys, etc., are excluded owing to the fat globules of their milk being excessive in size and not sufficiently discrete. Various other factors are taken into consideration, such as steadiness of yield, quantity of milk produced per diem, etc.

The cows are systematically examined to ensure that they are in good health, special attention being paid to the condition of the udder. In the event of any affection that is likely to militate against the purity of the milk being found, the cow is immediately isolated.

Dietary of Cows.—The dieting of the cows is carried out on a systematic and scientific basis which makes for both efficiency and economy. Even the most intelligent and conscientious farm bailiff, as generally found, knows very little about this subject. Any experience he has is entirely empirical, and, in consequence, special pains are taken to assist the bailiff in this respect. The cow not only requires to be studied as regards her condition and milk-yield, but the fact that her milk is to be used for infant feeding has also to be taken into consideration. Many of the foods commonly used, such as oil-cake, brewers' grains, and distillery grains, are strictly forbidden on account of their extremely prejudicial effect on the infant.

Grass, hay, pea-meal, bean-meal, mangolds, are some of the chief articles used, care being exercised to prevent an

6

undue proportion of mangolds or green food, as these are only allowable in very moderate amount—just sufficient to make the food succulent. The amount and proportion of the various ingredients is carefully adjusted, so as to maintain a proper balance between the fats, carbohydrates, and proteins. A typical winter diet is shown in the following table, which gives the average ration of each cow for one day:

Bran - - -	2	pounds
Bean-meal - - -	2	,,
Crushed oats - -	6	,,
Hay - - -	20	,,
Mangolds - - -	10	,,

Milking.—The process of milking is carried out as nearly as possible on the principles of aseptic surgery. The milkers thoroughly wash their hands and wear sterilized overalls, while all the vessels used in milking are sterilized by steam prior to use. Each cow is milked into a separate pail of special construction, which is designed so as to protect the milk as much as possible from any dirt or hair falling from the cow. It is provided with a cover which is placed on the pail immediately the cow is milked. The milk from each cow is successively and *immediately* transferred to the separating and refrigerating rooms situated in a block of buildings some 30 yards from the milking-sheds.

The warm milk is then passed through a power-driven separator, whence it emerges as (1) fat-free milk and (2) cream. The milk and cream are then immediately reduced by means of refrigerating machinery to a temperature of 38° F. (Fig. 4).

This stage, of critical importance in regard to the handling and transport of milk, is accomplished in a very few minutes, so that within about five minutes of the milk leaving the milking-sheds it is separated into fat-free milk and cream, reduced to a temperature only 6° above the freezing-point of water, and placed in specially-constructed churns for transport by rail to the hospital.

PLATE II.

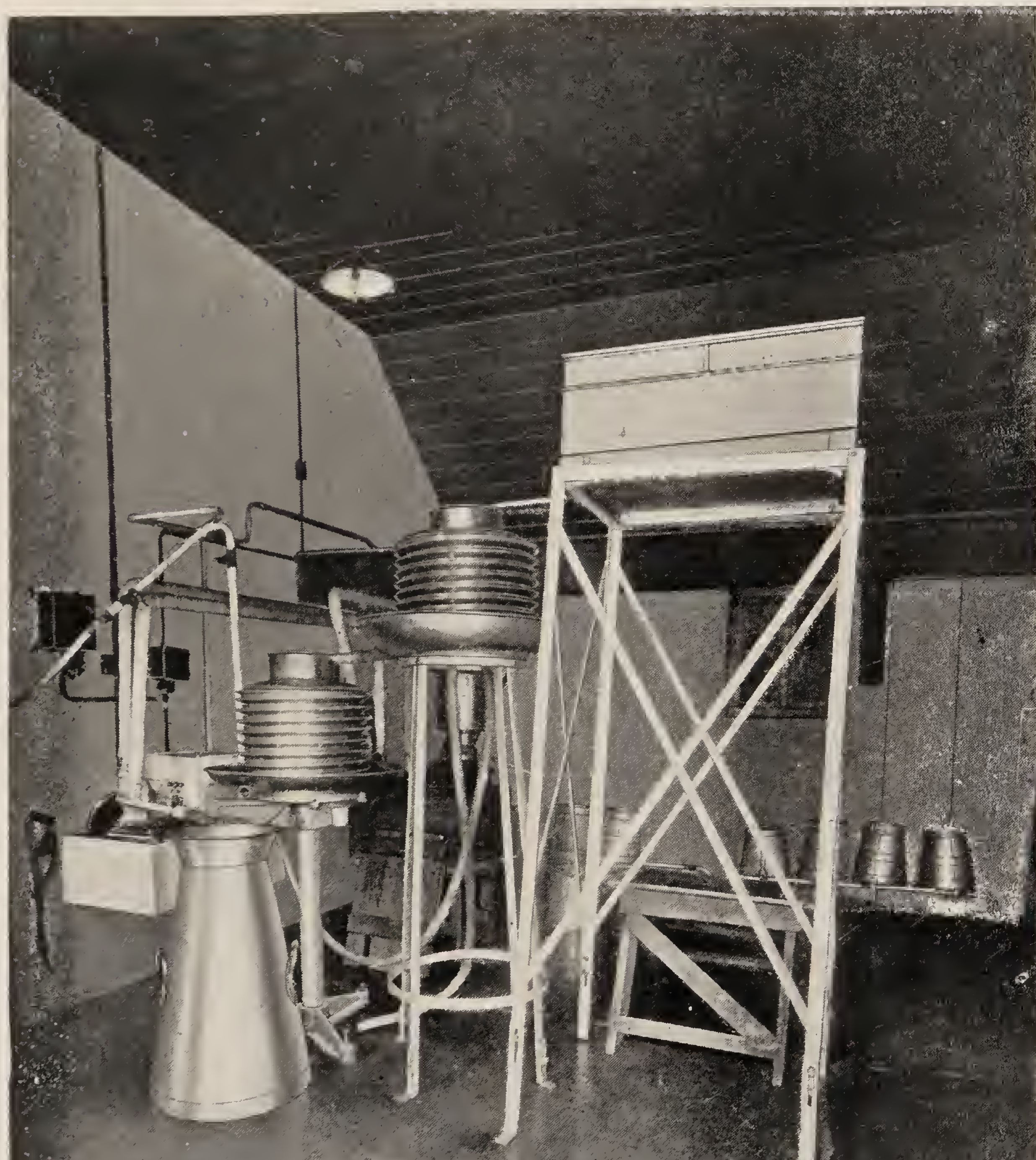

FIG. 4.—MILK REFRIGERATING APPARATUS.

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The transmission by rail of milk and cream at a temperature which is some 30° or more below that of the external air calls for special arrangements to protect them from the access of external heat.

The churns are constructed throughout with a double wall. Between the outer and the inner wall is a layer of enclosed air. Owing to the extremely low specific heat of air, this layer of still air acts as an efficient insulator, preventing any serious rise in the temperature of the contents.

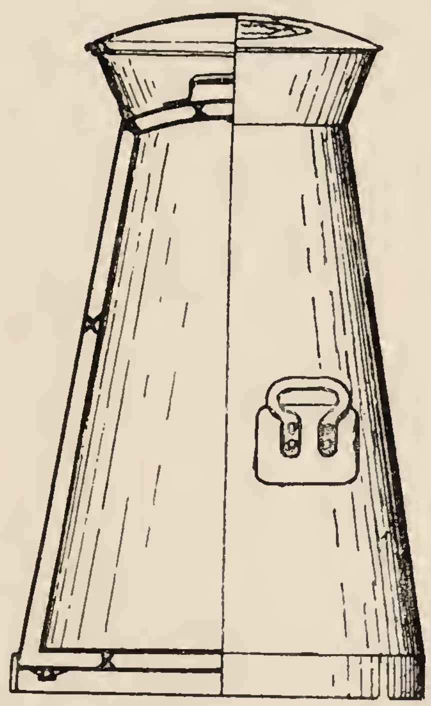

FIG 5.—DIAGRAM SHOWING THE CONSTRUCTION OF THE CHURNS USED FOR TRANSPORTING THE MILK FROM THE FARM TO THE HOSPITAL

The construction of the churn is shown in the figure (Fig. 5). The insulation by air is apparently the only efficient means of insulation. The use of materials such as 'slag wool' renders the sterilization of the churns by steam impracticable, as the insulating material takes up the heat, and in consequence, when the cold milk is put in the churn, it is raised in temperature by the retained heat of the insulating material.

Milk Laboratory.—On arrival at the hospital the cream is tested in order to determine the amount of fat it contains. This having been ascertained, the cream is then

standardized by the addition of a greater or less amount of fat-free milk, so as to contain a definite percentage of fat.

Whey is prepared from the fat-free milk. A standard solution of lactose is prepared. Sterile water is obtained by means of a Pasteur-Chamberland filter, and lime-water is prepared from pure calcium hydrate (made from marble). The solutions and ingredients so prepared are placed in metal tanks, filled at the back with ice-containing chambers, and from these standardized solutions the milk mixture for each infant is prepared (Fig. 6). The diet prescription for each infant is transmitted to the milk laboratory from the wards in the following form:

WARD II. INFANT NO. 18.

	Per Cent.
Fat - - - - -	1·50
Lactose - - - -	5·50
Whey proteins - -	0·50
Caseinogen - - -	0·25
Alkalinity - - -	5·00

Ten tubes, each of 4 ounces.

In the laboratory the prescription is translated into actual amounts. Thus, the translation of the above prescription is as follows:

	c.c.
Cream (32 per cent.) - - -	56
Fat-free milk - - - - -	71
Lime-water - - - - -	60
Lactose (20 per cent. solution) -	152
Whey - - - - - -	536
Water - - - - - -	325

The milk mixture so constructed is then carefully put up into separate bottles, one for each feed. Some 57,000 different combinations are provided for, and the tables comprising the first 15,000 are in frequent use.

Since milk was intended by Nature to be transferred directly from the mother to the offspring, it is essential that the measures adopted for the storage of milk should

PLATE III.

FIG. 6.—MILK LABORATORY: THE MODIFYING ROOM.

FIG. 7.—MILK LABORATORY: THE APPARATUS-STERILIZING ROOM.

To face page 84.

be of such a character that its natural properties are uninjured. The exposure of milk to ordinary temperatures involves a rapid development of bacteria, with the conse-

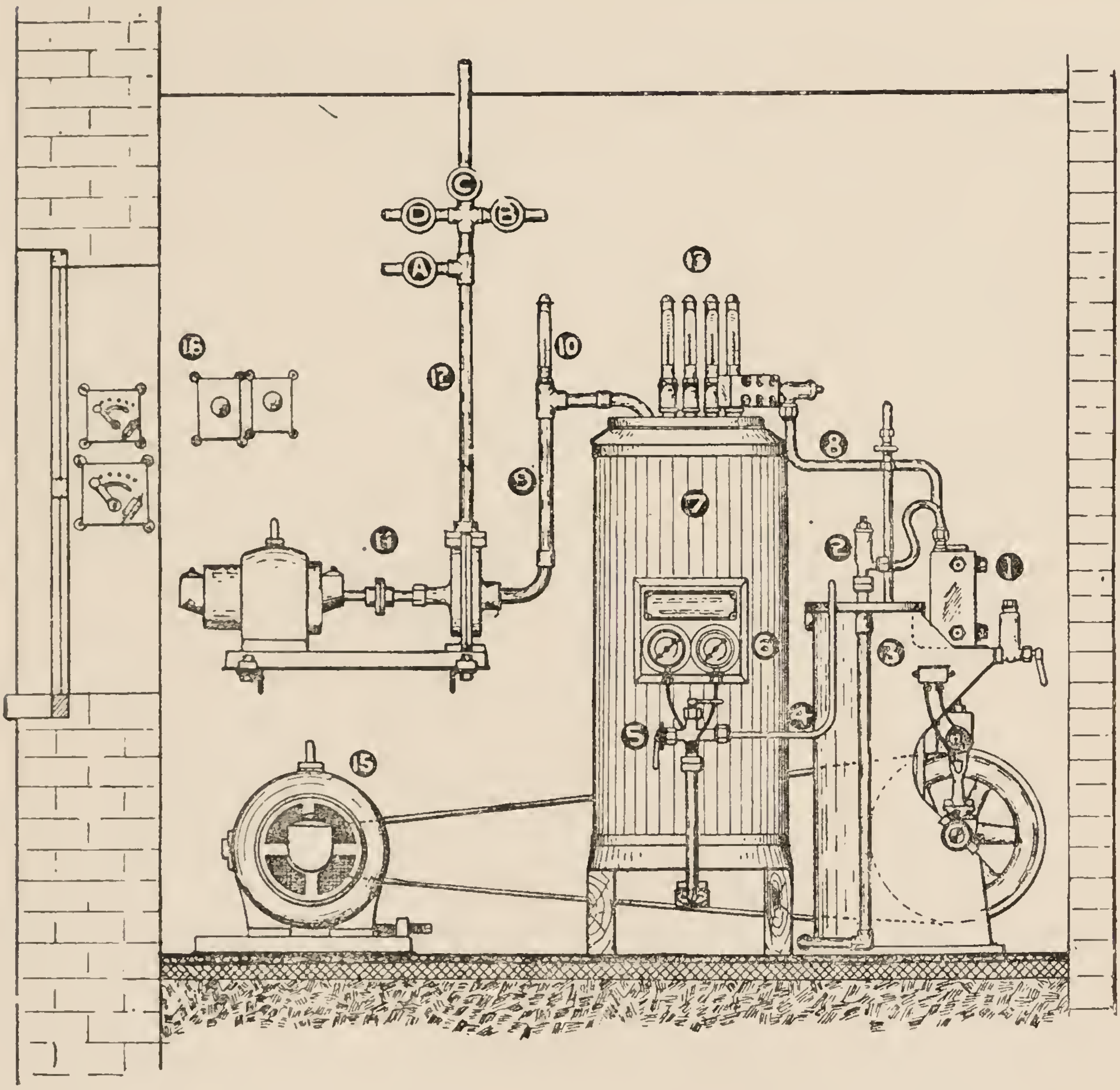

FIG. 8.—DIAGRAMMATIC SKETCH OF THE REFRIGERATING MACHINERY.

(1) Compressor in which CO_2 is compressed to (*circ.*) 60 atmospheres; (2) Condenser liquefying gas; (4) Pipe conveying liquid CO_2 to (5) Valve regulating admission of liquid to (7) Evaporator tank in which the brine is refrigerated; (8) Suction-pipe in which the evaporated liquid is returning as gas to the compressor; (9) Delivery to centrifugal pump distributing the refrigerated brine throughout the system; (10) Thermometer registering temperature of outgoing brine; (11) Motor driving the centrifugal pump; (12) Chief distributing main; —A, B, C, D, Mains to various rooms; (13) Thermometers registering temperature of brine returning from rooms; (15) Motor driving compressor pump; (16) Switches and rheostats.

quence that changes occur in the composition of the milk as a result of the bacteria living in and upon it. It is

therefore necessary to keep the milk at a temperature at which these processes cannot take place—*i.e.*, at a temperature not exceeding 40° F. It is also important that all the vessels used in connection with the preparation of the milk should be extremely clean, and all the churns, tanks, vessels, bottles, etc., are first thoroughly washed, and are then sterilized by steam prior to use (Fig. 7).

The maintenance of the low temperatures is accomplished by means of refrigerating machinery specially designed to meet the precise requirements by the refrigerating engineers to the hospital (Fig. 8).

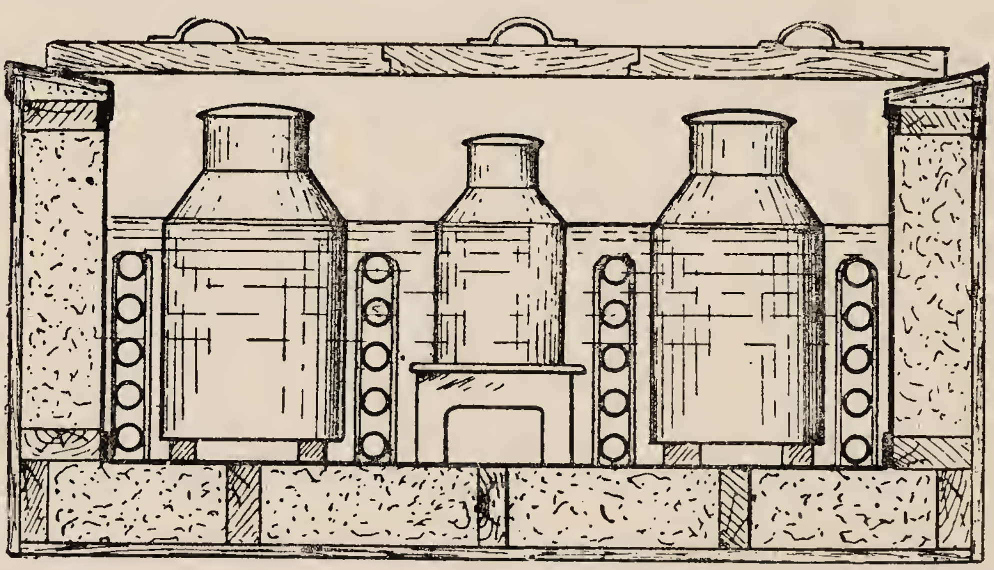

FIG. 9 —COOLING TANK FOR REDUCING SOLUTIONS TO THE REQUIRED TEMPERATURE: AN INSULATED TANK CONTAINING BRINE.

Within this are arranged a series of 'grids' through which brine is pumped from the evaporator tank. This cools the brine external to the grids, and this in turn lowers the temperature of the fluid contained in the metal vessels immersed in the brine.

The work of the refrigerating machinery is as follows:

1. The manufacture of ice for use in the modifying room. The ice is made of the exact shape required, thus making for economy as the waste due to breakage of the ice is avoided.
2. The maintenance of the milk in the storage cabinets attached to the modifying room and to each ward at a temperature not exceeding 40° F.

3. The reduction of all solutions used in the modifying room to a temperature not exceeding 40° F. This applies to the whey, lactose solution, and the sterile water (Fig 9).

One of the practical difficulties encountered in cold storage is the great loss of cold incurred by the opening of the cold store. This is generally provided for by 'air-locks.' Such a device would have been extremely unpractical in the case of a store so frequently resorted to as that containing the food of some twenty-five babies (the number of infants in each ward). The problem to be solved was—

1. To render easy of access each tube of milk for each infant.
2. To enable it to be obtained from the cold store without exposing the contents of the store to a rise of temperature.

These requirements are provided for as follows: The storage cabinets are small rooms heavily insulated on all sides. From the roof are suspended the drums containing the refrigerating agent—brine at a temperature of about 15° F. The main door is heavily insulated, and is large enough to permit of the room being entered for cleaning purposes. This door is never opened except for this purpose, and is kept locked.

A small door is fitted into the large door about 4½ feet above the floor-level. The situation of the door at this height prevents the loss of cold occurring, as the cold air escapes from the lowest point of the store. Inside this room is fitted a large wheel which is turned from outside. On the circumference of the wheel are fitted bars supporting 'carriers,' and each carrier contains four baskets, all numbered so that they can be identified from outside by looking through the glass in the small door. All that the

nurse has to do to obtain a particular bottle is to turn the handle outside till the basket she seeks is brought opposite the door; she then opens the door and takes the bottle.

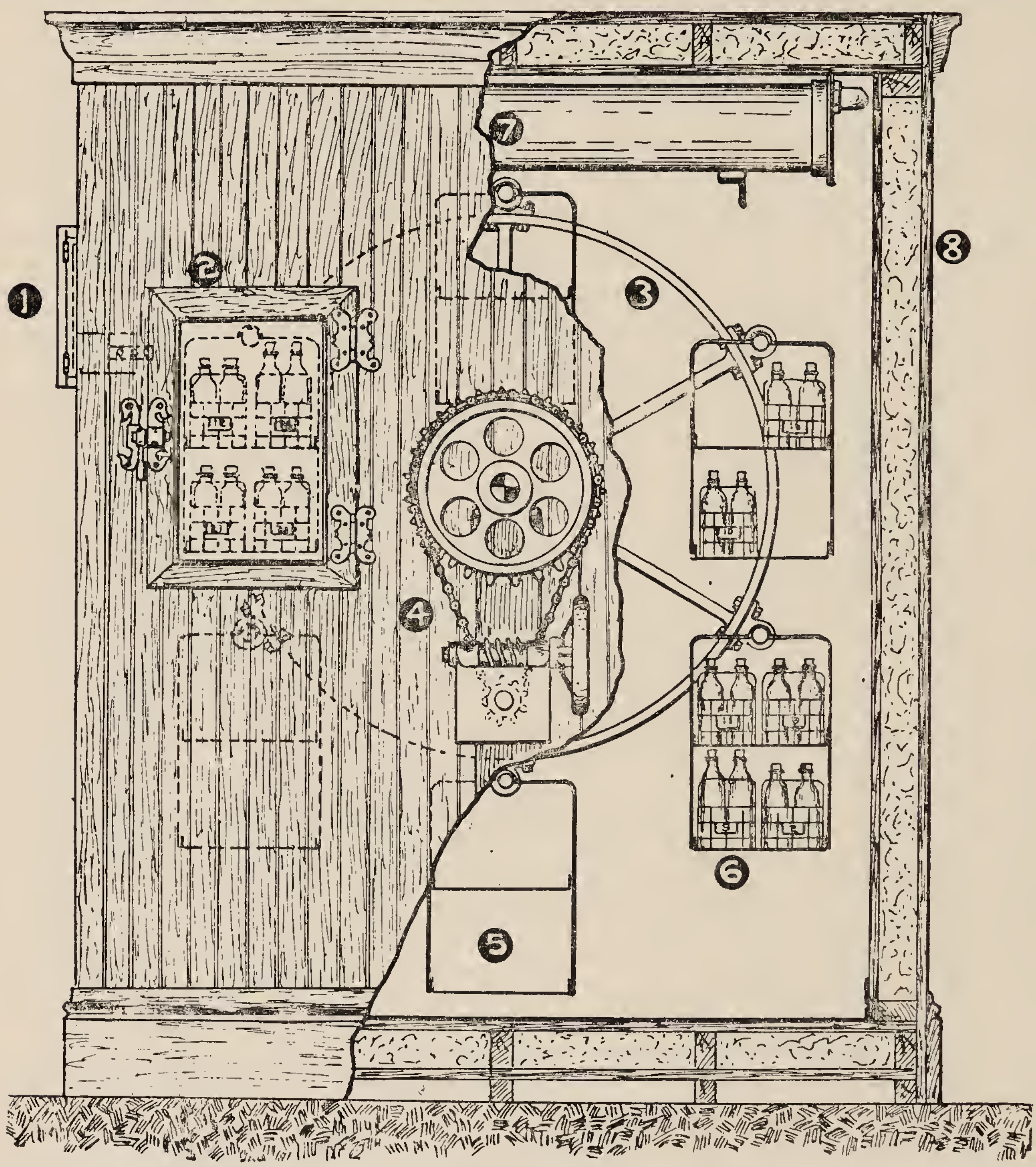

FIG. 10.—DIAGRAMMATIC SKETCH SHOWING THE CONSTRUCTION OF THE COLD STORES.

(1) Thermometer; (2) Small door with three panes of glass, still air separating the middle pane from the outer and inner panes; (3) Wheel; (4) Gear and turning mechanism; (5) Empty carrier; (6) Carrier loaded with baskets; (7) One of the drums containing brine; (8) Insulated wall.

This operation is effected without causing any appreciable rise of temperature in the room as indicated by the thermometer. In fact, when the room is stocked in the

evening with a fresh supply for the next twenty-four hours, the temperature is but little affected, the maximum rise that has been recorded in these circumstances being 1° F.

As the hospital milk laboratory serves only the hospital requirements, it is necessary to describe the arrangements for private cases. For these the necessary provision

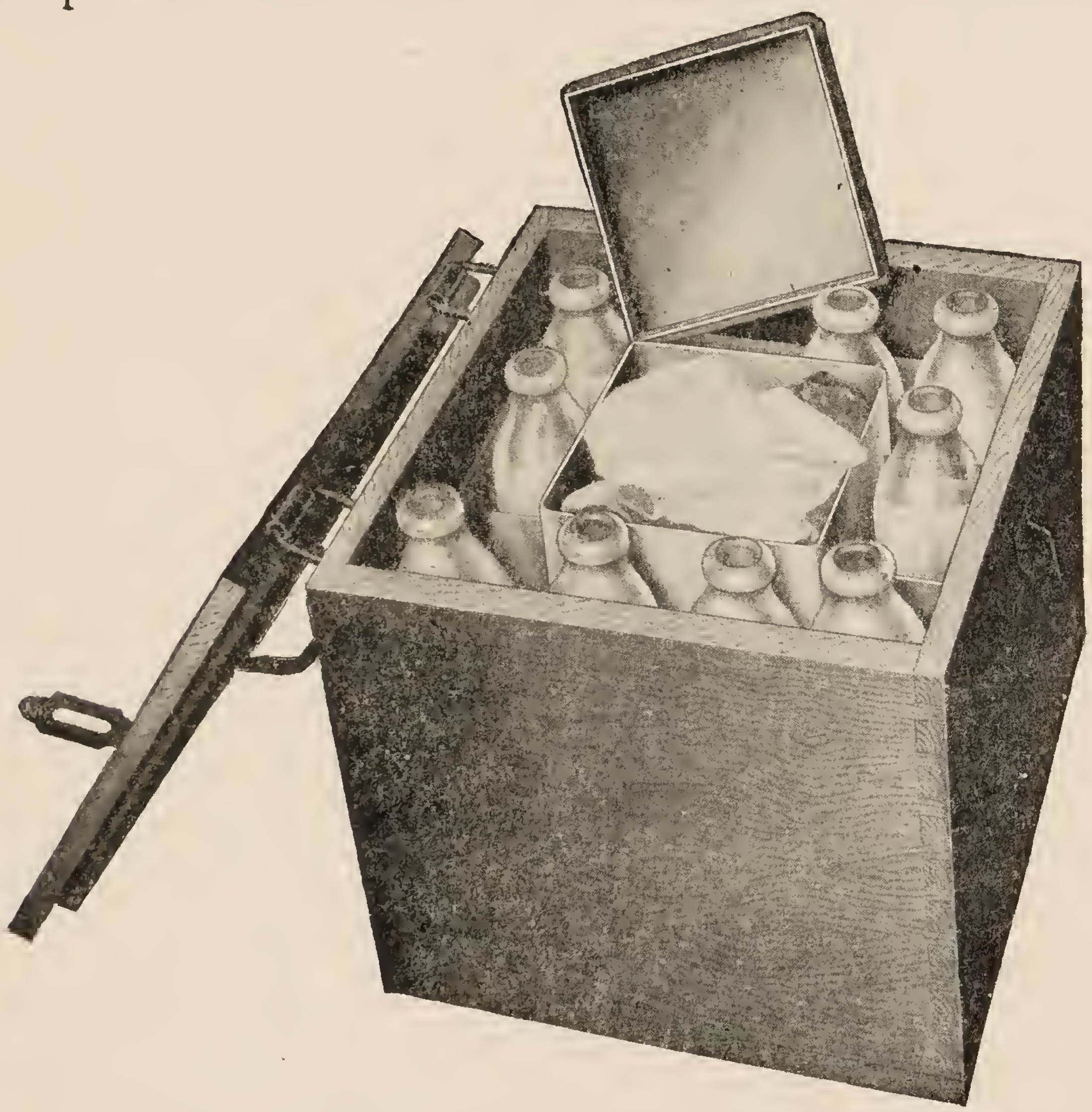

FIG. 11.—ICE-BOX FOR DESPATCH OF MODIFIED MILK.

is made by the Walker-Gordon Laboratories, Ltd.,[1] the arrangements of whose farm and laboratory closely correspond in general principle with those of the hospital. The farm belonging to the laboratory is the Sudbury Park Farm, Wembley, and the buildings and general arrangements were designed in the year 1902, to comply

[1] Of Weymouth Street, London.

with the author's requirements. Special arrangements are made in reference to the systematic daily despatch of the milk mixtures, and as the prescriptions of the author almost invariably call for *unheated* milk, the tubes are sent out in ice-boxes so that they may be protected, during transit and in the home, from rise of temperature (Fig. 11).

The methods adopted in the milk laboratory represent the results of practical experience of all the important details involved in infant feeding, and when applied with judgment and knowledge have been attended with success of the highest character.

But it must be said that the laboratory does nothing more than provide the medical profession with an extremely efficient instrument. Whether the results in any given case are successful or not entirely depends upon the way in which this instrument is used. It is, of course, obvious that unless the prescribed milk mixture is suited to the physiological requirements of the infant failure must ensue. It is essential that the traditional ideas associated with the old rule-of-thumb methods should be entirely given up, and that the exact conditions should be diagnosed with accuracy and precision.

To criticise a laboratory milk on the ground that it does not agree with the infant is as senseless as to blame the chemist for the failure of a medicine dispensed by him in accordance with a prescription. In the adjustment of the diet of the infant, a clear understanding of the essential factors combined with clinical experience is of the first importance. While nothing can take the place of clinical observation, there are, however, many points of practical importance in milk-prescribing, and these need to be discussed.

The Milk Prescription.—The milk prescription should specify clearly the percentage of fat, of lactose, of proteins, and of alkalinity, required, the number of feedings, and the amount of each feeding. It should also explicitly

state whether the mixture is to be heated or not, and, if it is to be heated, the precise temperature and time of exposure must be indicated.

Division of the Proteins.—In the previous chapter reference has already been made to the important differences between the albuminoids present in cow's milk and in human milk, and also to the great value of whey in respect of the nitrogenous extractives. For young infants the proteins need to be divided, and the amount of the whey proteins and of caseinogen must therefore be definitely specified. In regard to this certain practical points require attention. As whey is obtained by means of the action of the rennin ferment on separated milk, it is always necessary to heat the whey so prepared: otherwise the continued action of the ferment would result in the precipitation of the caseinogen when this was added to the mixture. The temperature of the whey need not be raised above 150° F., as the rennin ferment is killed at about 140° F.

Whey.—White and Ladd[1] published some valuable observations in regard to whey cream mixtures, and their conclusions were as follows:

'1. By the use of whey as a diluent of creams of various strengths we are able to modify cow's milk so that its proportions of caseinogen and whey proteins will closely correspond to the proportions present in human milk. We can in this way render it much more digestible and suitable for infant feeding.

'2. The best temperature for destroying the rennet enzyme in whey is 65·5° C. Whey or whey mixtures should not be heated above 69·3° C. in order to avoid coagulation of the whey proteins. The percentage of whey proteins in the whey obtained by us was 1 per cent., while in the analysis of the whole milk, approximately

[1] *Philadelphia Medical Journal*, February, 1901.

three-quarters of the total protein was caseinogen and one-quarter was whey protein.

'3. On the basis of these analyses we were able to obtain whey-cream mixtures, with a maximum of 0·90 per cent. and a minimum of 0·25 per cent. of whey proteins in combination with percentages of caseinogen varying from 0·25 per cent. to 1·00 per cent.; of fats, from 1·00 per cent. to 4·00 per cent.; of milk sugar, from 4·00 per cent. to 7·00 per cent.

'4. The emulsions of fat in whey, barley-water, gravity cream, and centrifugal cream mixtures, were the same, both in their macroscopic and microscopic appearances. The combination of heat and transportation, such as sometimes occurs in hot weather, partially destroys the emulsion in all forms of modified milk, but this disturbance can be prevented by the simple precaution of keeping the milk cool during delivery.

'5. Whey-cream mixtures yield a much finer, less bulky, and more digestible coagulum than plain modified mixtures with the same total proteins; the coagulum is equalled in fineness only by that of barley-water mixtures. The coagulum yielded by gravity cream mixture and centrifugal cream mixtures is the same in character.'

Laboratory Calculations.—In the construction of a divided protein mixture at the laboratory, the calculations involved are somewhat elaborate. For instance, the amount of sugar present in the whey and in the cream has to be accurately determined before the percentage can be adjusted by the addition of lactose. This and many other points are provided for by tables in use at the laboratory. But it is necessary to bear in mind certain facts in relation to these combinations.

Fat can only be added by the use of cream. This necessarily contains both caseinogen and lactalbumin, so that much depends on the precise quality of the cream

THE PRACTICAL COMPOSITION OF CERTAIN PERCENTAGE MIXTURES.

No.	20-ounce Mixtures. Percentage of—				Ounces of Cream.				Ounces of Fat-free Milk used with Creams of—				Ounces.		Lactose Measure.	Lactose per Cent., without Dry Lactose.
	Fat.	Lactose.	Proteins.	Alk.	10 per Cent.	12 per Cent.	16 per Cent.	20 per Cent.	10 per Cent.	12 per Cent.	16 per Cent.	20 per Cent.	Lime-Water.	Boiled Water.		
1	1·50	4·50	0·25	5	*	*	*	1½	*	*	*	0	1	17½	2	0·33
2	1·50	4·50	0·50	5	3	2½	2	1½	0	½	1	1½	1	16	2	0·61
3	2·00	5·00	0·25	5	*	*	*	2	*	*	*	0	1	17	2¼	0·75
4	2·00	5·00	0·50	5	*	3¼	2½	2	*	0	½	1	1	15¾	2¼	0·73
5	2·00	5·00	0·75	5	4	3¼	2½	2	¾	1½	2¼	2¾	1	14½	2	1·01
6	2·00	5·50	1·00	5	4	3¼	2½	2	1¾	2½	3¼	3¾	1	13¼	2¼	1·30
7	2·50	5·00	0·50	5	*	*	3¼	2½	*	*	0	¾	1	15¾	2¼	0·73
8	2·50	5·50	0·75	5	*	4¼	3¼	2½	*	¼	1¼	2	1	14½	2¼	1·01
9	2·50	6·00	1·00	5	5	4¼	3¼	2½	1	1¾	2¾	3½	1	13½	2½	1·23
10	3·00	6·00	0·50	5	*	*	3¾	3	*	*	0	¾	1	15¼	2½	0·84
11	3·00	6·00	0·75	5	*	5	3¾	3	*	0	1¼	2	1	14	2½	1·12
12	3·00	6·00	1·00	5	6	5	3¾	3	0	1	2¼	3	1	13	2¼	1·35
13	3·00	6·00	1·25	5	6	5	3¾	3	1¼	2¼	3½	4¼	1	11¾	2¼	1·35
14	3·00	6·50	1·50	5	6	5	3¾	3	2½	3½	4¾	5½	1	10½	2¼	1·91
15	3·00	6·50	2·00	5	6	5	3¾	3	5½	6½	7¾	8½	1	7½	2	2·68
16	3·50	6·00	0·50	5	*	*	*	3½	*	*	*	0	1	15½	2½	3·78
17	3·50	6·00	0·75	5	*	*	4½	3½	*	*	0	1	1	14½	2½	1·01
18	3·50	6·50	1·00	5	*	5¾	4½	3½	*	0	1¼	2¼	1	13¼	2½	1·26
19	3·50	6·50	1·25	5	7	5¾	4½	3½	½	1¾	3	4	1	11½	2½	1·68
20	3·50	6·50	1·50	5	7	5¾	4½	3½	2	3¼	4½	5½	1	10	2¼	2·02
21	4·00	6·00	0·60	5	*	*	*	4	*	*	*	0	1	15	2½	0·78
22	4·00	6·00	0·75	5	*	*	5	4	*	*	0	1	1	14	2½	1·12
23	4·00	7·00	1·00	5	*	*	5	4	*	*	1	2	1	13	2¾	1·35
24	4·00	7·00	1·25	5	*	6¾	5	4	*	¾	2½	3½	1	11½	2½	1·68
25	4·00	7·00	1·50	5	8	6¾	5	4	1	2¼	4	5	1	10	2½	2·02
26	4·00	7·00	2·00	5	8	6¾	5	4	3½	4¾	6½	7½	1	7½	2¼	2·56
27	4·00	7·00	2·50	5	8	6¾	5	4	6¼	7½	9¼	10¼	1	4¾	2	3·20
28	4·00	7·00	3·00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	1½	3·88
29	4·00	6·00	3·00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	1	3·88
30	4·00	5·50	3·00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	¾	3·88

For 25-ounce mixtures multiply the amount of each ingredient by 1¼
,, 30 ,, ,, ,, ,, ,, ,, 1½
,, 35 ,, ,, ,, ,, ,, ,, 1¾

For 40-ounce mixtures multiply the amount of each ingredient by 2
,, 45 ,, ,, ,, ,, ,, ,, 2¼

* Combination impossible with strength of cream indicated.

THE POSSIBLE VARIATIONS OF MIXTURES WITH DIVIDED PROTEINS.

Fat.	Whey Protein.	Caseinogen.	Fat.	Whey Protein.	Caseinogen.
1·0	0·50	0·25	2·5	0·90	0·60
1·0	0·75	0·25	2·5	0·75	0·75
1·0	0·90	0·25	2·5	0·90	0·75
1·0	0·50	0·50	2·5	0·90	1·00
1·0	0·75	0·50	2·5	0·50	0·25
1·0	0·90	0·50	2·5	0·75	0·25
1·0	0·50	0·60	3·0	0·90	0·25
1·0	0·75	0·60	3·0	0·50	0·50
1·0	0·90	0·60	3·0	0·75	0·50
1·0	0·75	0·75	3·0	0·90	0·50
1·0	0·90	0·75	3·0	0·50	0·60
1·0	0·90	1·00	3·0	0·75	0·60
1·5	0·50	0·25	3·0	0·90	0·60
1·5	0·75	0·25	3·0	0·75	0·75
1·5	0·90	0·25	3·0	0·90	0·75
1·5	0·50	0·50	3·0	0·90	1·00
1·5	0·75	0·50	3·0	0·50	0·25
1·5	0·90	0·50	3·0	0·75	0·25
1·5	0·50	0·60	3·5	0·90	0·25
1·5	0·75	0·60	3·5	0·50	0·50
1·5	0·90	0·60	3·5	0·75	0·50
1·5	0·75	0·75	3·5	0·90	0·50
1·5	0·90	0·75	3·5	0·50	0·60
1·5	0·90	1·00	3·5	0·75	0·60
2·0	0·50	0·25	3·5	0·90	0·60
2·0	0·75	0·25	3·5	0·75	0·75
2·0	0·90	0·25	3·5	0·90	0·75
2·0	0·50	0·50	3·5	0·90	1·00
2·0	0·75	0·50	3·5	0·50	0·60
2·0	0·90	0·50	3·5	0·75	0·60
2·0	0·50	0·60	4·0	0·90	0·60
2·0	0·75	0·60	4·0	0·75	0·75
2·0	0·90	0·60	4·0	0·90	0·75
2·0	0·75	0·75	4·0	0·90	1·00
2·0	0·90	0·75	4·0	0·50	0·25
2·0	0·90	1·00	4·0	0·75	0·25
2·5	0·50	0·25	4·0	0·90	0·25
2·5	0·75	0·25	4·0	0·50	0·50
2·5	0·90	0·25	4·0	0·75	0·50
2·5	0·50	0·50	4·0	0·90	0·50
2·5	0·75	0·50	4·0	0·50	0·60
2·5	0·90	0·50	4·0	0·75	0·60

Any percentage of lactose from 4 to 7 may be obtained with any of the above combinations.

used. The average composition of a 16 per cent. cream is—

	Per Cent.
Fat - - - -	16·00
Lactose - - - -	4·20
Proteins - - - -	3·05

With a cream of higher percentage the amount required to provide the specified fat content is necessarily less, and therefore the percentage of caseinogen added to the mixture is correspondingly diminished. The table on p. 96, formulated by Ladd, illustrates the various factors that need to be accurately estimated. Thus, when a maximum amount of whey proteins is required with a minimum amount of caseinogen, the cream used must be in a concentrated form—such, for instance, as 32 per cent. Further, the amount of the total proteins present is definitely limited by the constitution of the whey and cream. This limitation is, however, of no practical disadvantage, since in the early months of the infant's life, when these mixtures are used, a high protein content is never indicated. The table on p. 97 shows some of the variations permissible.

These tables show how numerous are the possibilities of graduation, yet, by making use of extremely high-percentage cream, the amount of caseinogen may be even further reduced. In the healthy infant this is never necessary, but in cases of inanition and marasmus, or of severe gastro-enteritis, the digestion may be so enfeebled that caseinogen requires to be reduced to the absolute minimum. The author, in these cases, has frequently found it advisable to reduce the caseinogen as low as 0·15 or 0·10 per cent. As soon as the digestion shows signs of recovery, the normal proportions can be gradually used.

Indications for Specific Adjustment.—The indications for the particular adjustment of the diet are essentially clinical and depend on a combination of factors varying

with each infant, so that it is extremely difficult, if not impossible, to lay down any general rules in this matter. They can best be illustrated, rather than precisely defined, by clinical facts, and in the following chapters these considerations receive attention.

The Various Methods of Infant Feeding.—As a result of the author's experience, he has had opportunities of studying almost every method at all commonly used. It is unnecessary to dwell upon his experiences with the '1 in 3' mixtures, with various combinations of whey and cream, such as that devised by Frankland, with other expedients in the shape of milk partially or entirely peptonized, or with the various diluents, such as barley, oatmeal, and rice water. Success or comparative success was, indeed, frequently obtained by the adjustment of the food of the infant by these methods in the light of clinical experience; but the result was always attended with uncertainty, and the lessons to be derived either from success or failure were, in general, too vague and indefinite to be of use in future cases.

The most emphatic condemnation of these traditional methods is to be found in the views of their exponents. Comparatively few have dealt with the problems in a wide and scientific spirit, and most have confined themselves to the advocacy of some favourite mixture. The reader will find a lengthy account of these various methods in Judson and Gitting's work. Amongst others, the views of Biedert, Heubner, Bendix, Henoch, and Baginsky, are quoted, as also are those of Monti, who 'criticises the methods of Heubner, Hofmann, and Soxhlet,' and advocates two mixtures, one for the first five months of life, and a second for older infants. These procedures are altogether out of harmony with our present knowledge. The clinical facts attending substitute feeding, when this is accurately carried out, are most striking. The attitude of the physician towards these

cases becomes entirely altered, and a subject the most vague and confused becomes precise and scientific.

Home Modification.—Where for any reason the exact methods of the laboratory are not available, the milk must be modified in the home. Cow's milk, clean and containing the constituents of milk in their right proportion, and containing nothing else, is the first essential. In town and country, nothing is so comparatively rare as the product answering to this description, and it is important that undue weight should not be attached to the representations of the milkman. As most adequate methods of modification depend on the addition of cream, etc., it is imperative that the vague term 'cream' be avoided, and some name be used indicating the character. Thus, the cream supplied for domestic purposes by the Walker-Gordon laboratories is known and described as a 32 per cent. cream—that is, a cream containing 32 per cent. of fat. Other creams, such as 16 per cent., can be provided. The precise quality is not so important as the knowledge of the percentage constitution. On the other hand, the cream supplied from the ordinary dairies appears to vary greatly.

The table on p. 98 shows how uncertain must be the quality of any milk mixture prepared by the addition of cream, unless the precise character of the cream be known. The amount of fat present in the mixture depends entirely upon the quality of the cream employed, and, as has already been illustrated, the protein-content is correspondingly affected. In a cream of low fat percentage the proteins are in comparatively large amount, and *vice versâ*.

In regard to the sugar that requires to be added, this should always be in the form of lactose. There is no difficulty in obtaining a supply of this constituent at a reasonable cost, and, as it keeps indefinitely, there is no excuse for the use of cane-sugar or other foreign material.

THE CONTENT OF MIXTURES IN RELATION TO THE CHARACTER OF THE CREAM USED.

Percentage of Cream.		Percentage of Fat in Mixture.		Lowest Possible Protein-Content.
10 per cent.	-	1 per cent.	-	0·38
10 „	-	2 „	-	0·67
10 „	-	3 „	-	1·00
10 „	-	4 „	-	1·34
12 „	-	1 „	-	0·27
12 „	-	2 „	-	0·54
12 „	-	3 „	-	0·82
12 „	-	4 „	-	1·08
16 „	-	1 „	-	0·20
16 „	-	2 „	-	0·40
16 „	-	3 „	-	0·60
16 „	-	4 „	-	0·80
20 „	-	1 „	-	0·15
20 „	-	2 „	-	0·31
20 „	-	3 „	-	0·46
20 „	-	4 „	-	0·62

An important practical point also needs attention in respect of those mixtures calling for the use of whey. In the laboratory this is always prepared from separated milk which contains but a trace of fat (0·13 per cent.). When whey is prepared from *whole milk* the fat percentage is very variable. Having regard to the delicate calculation involved when whole milk is used, it is much better to use fresh separated milk for the preparation of the whey, and to obtain the required fat percentage by the addition of cream. The *lower* the protein content of the mixture, the *higher* the fat percentage of the cream should be in order to avoid adding excess of proteins.

The following table gives the percentage composition of some of the mixtures most frequently used, together with their translation into the actual amounts of each ingredient. Where the laboratory cannot be used, these figures may be of service in enabling a mixture to be prepared the percentage composition of which may be approximately known. The mixtures in this table are made up to 1,200 c.c. (rather more than 40 ounces). The cream used is one containing 32 per cent. of fat.

PRESCRIBED MIXTURES AND THEIR ACTUAL COMPOSITION.

I.

	Per cent.		C.C.
Fat	1·00	Cream	37
Lactose	5·00	20% solution	120
Whey proteins	0·50	Whey	601
Caseinogen	0·10	Fat-free milk	18
Alkalinity	5·00	Lime-water	60
		Water	363

II.

Fat	1·50	Cream	56
Lactose	6·00	20% solution	180
Whey proteins	0·50	Whey	602
Caseinogen	0·10	Fat-free milk	5
Alkalinity	5·00	Lime-water	60
		Water	296

III.

Fat	2·00	Cream	75
Lactose	6·50	20% solution	212
Whey proteins	0·50	Whey	536
Caseinogen	0·25	Fat-free milk	59
Alkalinity	5·00	Lime-water	60
		Water	259

IV.

Fat	2·00	Cream	75
Lactose	6·50	20% solution	121
Whey proteins	0·75	Whey	858
Caseinogen	0·25	Fat-free milk	59
Alkalinity	5·00	Lime-water	60
		Water	27

V.

Fat	2·00	Cream	75
Lactose	6·50	20% solution	124
Whey proteins	0·75	Whey	748
Caseinogen	0 50	Fat-free milk	168
Alkalinity	5·00	Lime-water	60
		Water	24

VI.

Fat	2·50	Cream	94
Lactose	6·50	20% solution	212
Whey proteins	0·50	Whey	536
Caseinogen	0·25	Fat-free milk	46
Alkalinity	5·00	Lime-water	60
		Water	253

PRESCRIBED MIXTURES AND THEIR ACTUAL COMPOSITION —*continued.*

VII.

	Per cent.		C.C.
Fat	2·50	Cream	94
Lactose	6·50	20% solution	121
Whey proteins	0·75	Whey	858
Caseinogen	0·25	Fat-free milk	46
Alkalinity	5·00	Lime-water	60
		Water	21

VIII.

Fat	3·00	Cream	112
Lactose	6·50	20% solution	122
Whey proteins	0·75	Whey	859
Caseinogen	0·25	Fat-free milk	33
Alkalinity	5·00	Lime-water	60
		Water	14

IX.

Fat	2·00	Cream	75
Lactose	6·50	20% solution	306
Proteins	1·00	Fat-free milk	275
Alkalinity	5·00	Lime-water	60
		Water	484

X.

Fat	2·00	Cream	75
Lactose	6·50	20% solution	285
Proteins	1·25	Fat-free milk	357
Alkalinity	5·00	Lime-water	60
		Water	423

XI.

Fat	2·00	Cream	75
Lactose	6·50	20% solution	264
Proteins	1·50	Fat-free milk	438
Alkalinity	5·00	Lime-water	60
		Water	363

XII.

Fat	2·50	Cream	94
Lactose	6·50	20% solution	285
Proteins	1·25	Fat-free milk	344
Alkalinity	5·00	Lime-water	60
		Water	417

PRESCRIBED MIXTURES AND THEIR ACTUAL COMPOSITION —*continued.*

XIII.

	Per cent.		C.C.
Fat - -	2·50	Cream -	94
Lactose -	6·50	20% solution	264
Proteins -	1·50	Fat-free milk	426
Alkalinity -	5·00	Lime-water	60
		Water -	357

XIV.

Fat - -	3·00	Cream -	112
Lactose -	6·50	20% solution	285
Proteins -	1·25	Fat-free milk	331
Alkalinity -	5·00	Lime-water	60
		Water -	411

XV.

Fat - -	3·00	Cream -	112
Lactose -	6·50	20% solution	264
Proteins -	1·50	Fat-free milk	413
Alkalinity -	5·00	Lime-water	60
		Water -	350

XVI.

Fat - -	3·50	Cream -	131
Lactose -	6·50	20% solution	264
Proteins -	1·50	Fat-free milk	400
Alkalinity -	5·00	Lime-water	60
		Water -	344

XVII.

Fat - -	4·00	Cream -	150
Lactose -	6·50	20% solution	285
Proteins -	1·25	Fat-free milk	306
Alkalinity -	5·00	Lime-water	60
		Water -	399

XVIII.

Fat - -	4·00	Cream -	150
Lactose -	6·50	20% solution	264
Proteins -	1·50	Fat-free milk	387
Alkalinity -	5·00	Lime-water	60
		Water -	338

XIX.

Fat - -	4·00	Cream -	150
Lactose -	7·00	20% solution	273
Proteins -	1·75	Fat-free milk	469
Alkalinity -	5·00	Lime-water	60
		Water -	248

PRESCRIBED MIXTURES AND THEIR ACTUAL COMPOSITION —*continued.*

XX.

	Per Cent.		C.C.
Fat - -	4·00	Cream -	150
Lactose -	7·00	20 % solution	252
Proteins -	2·00	Fat-free milk	551
Alkalinity -	5·00	Lime-water	60
		Water -	187

The Fat-Whey Method.—Milk mixtures prepared in a laboratory or involving the purchase of cream, milk-sugar, etc., are too expensive for the multitude, and the great majority of substitute-fed infants must be dependent on a milk mixture prepared in the home from inexpensive materials. The method of home modification recommended by the author as the one most adequately fulfilling the requirements is the 'Fat-Whey' method. This method was devised by him as the result of numerous experiments in the Research Laboratory of The Infants Hospital, and has been extensively used in the out-patient department. Fat-whey is prepared as follows: Rennin is added to cow's milk when cold. The milk is then raised to 100° F., being continually stirred with a large spoon. This stirring is important, for it prevents the curd forming dense lumps, and enables the fat globules to remain in the fluid instead of being entangled in the curd. The curd is then pressed with a spoon till it forms a tough mass at the bottom of the jug. Finally, the whey is heated to 150° F., in order to destroy the rennin, as otherwise the ferment would curdle the milk added to the whey in the preparation of the milk mixture.

This fat-whey, when properly prepared, contains so much fat that it is quite opaque, and cannot be distinguished, in regard to its appearance, from whole milk. As it is impracticable in many cases to specify a precise temperature such as 150° F., instructions are

given which secure that this temperature is reached. The following is a copy of the leaflet issued in the out-patient department:

THE INFANTS HOSPITAL.

INSTRUCTIONS FOR PREPARING WHEY.

1. Add 4 drops of the special rennin supplied to 1 quart of milk.[1]

N.B.—The milk must be quite fresh. It must not be boiled or sterilized or pasteurized, and must not have any preservative in it.

2. After adding the rennin, warm the milk in a clean jug surrounded by water in a saucepan. When the milk is at blood temperature (100° F.), remove the saucepan from the fire.

3. Stir the milk in the jug until the curds are well formed; at the same time press them to the bottom of the jug with a spoon.

4. When the curds are formed into a solid mass at the bottom of the jug, place the saucepan again on the fire and boil the *water* round the jug for one minute.

5. Pour off the whey, and use as directed.

The whey thus prepared contains a large proportion of the fat and the whole of the lactose and whey-proteins present in cow's milk. Prepared from a milk containing 4 per cent. of fat, the composition of the whey is approximately as follows:

	Per Cent.
Fat - - - - -	2·50
Lactose - - - -	5·00
Whey-proteins - - -	1·00
Caseinogen - - -	nil

The requisite proportion of caseinogen required is provided by the addition to the whey of the necessary amount of milk. The two following abstracts of cases from the out-patient department of The Infants Hospital show in detail the application of the method. In the

[1] The rennin supplied is Hansen's Extract of Rennet, which is much more powerful than the ordinary extracts. Parke Davis's rennin tablets are powerful and convenient.

first case a delicate infant is ordered a mixture of fat-whey, water, and milk, the mixture being gradually strengthened. In the second case a more vigorous infant is fed on fat-whey and milk, the proportion of whey being lessened as the infant progresses.

CASE 6,119: K. B., AGED 2½ MONTHS.

Date.	Weight. lb.	oz.	Milk Mixtures.
August 29	7	10	Fat-whey, 3 parts. Water, 3 parts. Milk, 1 part. Sugar, 1 lump.
August 31	7	7	—
September 2	7	7	Fat-whey, 4 parts. Water, 2 parts. Milk, 1 part. Sugar, 1 lump.
September 6	7	8	—
September 13	8	9	Fat-whey, 5 parts. Water, 2 parts. Milk, 1 part. Sugar, 1 lump.
September 20	9	1	Fat-whey, 2 parts. Water, 2 parts. Milk, 1 part. Sugar, 1 lump.
September 27	9	8	—
October 11	10	6	—

CASE 5,448: W. H., AGED 7 MONTHS.

Date.	Weight. lb.	oz.	Milk Mixtures.
June 24	7	14	Fat-whey, 4 parts. Milk, 2 parts. Sugar, 1 lump.
June 29	8	5	—
July 6	8	9	—
July 13	9	1	—
July 27	9	7	Fat-whey, 3 parts. Milk, 3 parts. Sugar, 1 lump.
August 3	10	1	—
August 24	11	0	Fat-whey, 3 parts. Milk, 4 parts.
September 5	11	1	—
September 14	11	8	—
September 21	12	1	—
September 28	12	10	—
October 12	13	4	—

Regulations of Substitute Feeding.—The general hygienic principles in regard to substitute feeding are the same as those applying to maternal nursing. The need for regularity in regard to the intervals is, of course, as great in the one as in the other. But the amount to be given to the infant when bottle-fed calls for careful discrimination and judgment. No set rules can be laid down ; one infant will require twice as much in amount as another infant of the same age, and the difference of amount may or may not be compensated for by a difference of quality in the substitute food. The table below shows the intervals of feeding and the amount of each feeding at the various ages. The figures are only to be regarded as an approximate guide, and must be adapted in practice to the actual requirements of the infant.

General Rules for Feeding during the First Year.

Age.	Interval.	Number of Feedings in 24 Hours.	Number of Night Feedings.	Amount at Each Feeding.	Total Amount in 24 Hours.
1 week	2 hours	10	1	1 ounce	10 ounces
2 weeks	2 "	10	1	1½ ounces	15 "
4 "	2 "	9	1	2½ "	22½ "
6 "	2½ "	8	1	3 "	24 "
8 "	2½ "	8	1	3¼ "	26 "
3 months	2½ "	7	0	4 "	28 "
4 "	2½ "	7	0	4½ "	31½ "
5 "	3 "	6	0	5½ "	33 "
6 "	3 "	6	0	5¾ "	34½ "
7 "	3 "	6	0	6¼ "	37½ "
8 "	3 "	6	0	7 "	42 "
9 "	3 "	6	0	7 "	42 "
10 "	3 "	5	0	8½ "	42½ "
11 "	3 "	5	0	8¾ "	43¾ "
12 "	3 "	5	0	9 "	45 "

Especial attention is called for in regard to all the appliances used. The indiarubber teats, after use, should be turned inside out and thoroughly cleansed with

boracic acid solution. It is a mistake, however, to keep them continuously in this solution, as the rubber is much damaged and is more likely to retain particles of decomposing milk. Care also should be taken to see that none of the boracic solution remains on the teat when used by the infant. To ensure this, immediately prior to the feeding the teat should be rinsed in plain water. It is scarcely necessary to say that bottles fitted with india-rubber tubing are to be totally condemned as altogether unfit for the purpose. The boat-shaped bottle may be used, but by far the most convenient form is that shown on p. 223 (Fig. 45). It is readily cleansed, and when properly fitted with an appropriate teat there is considerable resistance to the egress of the milk, thus imitating, to some extent, the natural method, and tending to prevent the infant obtaining its food too rapidly, which is one of the common incidents of bottle-feeding.

In reference to the laboratory mixtures, the nurse should be specially cautioned that the full amount prescribed is not to be given, when the infant shows that it is satisfied before the tube is emptied. It is, of course, impossible to dictate to the infant that it shall take precisely the same amount at each feed. But the nurse, in view of the definite amount supplied in each tube, is apt to regard this as an instruction to her to see that the full amount is taken by the infant. This misconception should be specifically guarded against. On the other hand, specific instructions should be given that she is not in any circumstances to increase the amount or to add anything to the food mixture as supplied, as such procedures may altogether nullify the care taken in preparing the food.

Premature Infants.

The premature infant requires peculiar care and attention. Infants born before the twenty-eighth week of gestation do not, as a rule, survive for more than a few

hours or days, in consequence of their absolute inability to maintain independent life. Cases, however, from time to time occur where infants survive though born considerably before this limit.

During the last three months of pregnancy the development of the fœtus is remarkably rapid, and in cases where the induction of premature labour is necessary the operation should not be performed until the maximum development that is consistent with safety has been attained.

The last fortnight of normal pregnancy is not attended, as a rule, by any marked increase in the size or weight of the infant; or, at least, the rate of development during these fourteen days is not comparable with that of the previous months.

Towards the termination of pregnancy, the fœtus appears to be undergoing a consolidation of tissue, and to be accumulating the power of resistance enabling it to maintain a separate existence. The infant at full term is more fully covered with vernix caseosa, its nails are longer, and it is stronger and more active than the infant born a fortnight before full term. In length and weight no great disparity exists, so that the infant of thirty-eight weeks' gestation of one mother may compare favourably with the healthy infant at full term of another mother.

In all cases of prematurity the two factors requiring persistent attention are the inherent weakness of vitality and the comparative inability to maintain animal heat. The infant should not be bathed, but should be anointed over the whole body with warm oil, and then swathed in cotton-wool that has been previously warmed.

Maintenance of Animal Heat.—The maintenance of the normal heat of the body is so important that unless this is attained the infant will almost certainly die. For this purpose an incubator is usually recommended. In the author's experience they are not desirable.

The objections to the incubator are that, despite the

most extreme precaution, it is almost impracticable to obtain natural ventilation, and the infant is necessarily subject to sudden changes of temperature when it has to be fed and attended to—occasions which are of exceptionally frequent occurrence. When practicable, a small room should be devoted to the purpose of providing a more natural form of incubator. It should be heated by a coal fire; the temperature of the room should be kept at the required degree, according to the necessities of the case, and a full supply of pure fresh air should be constantly maintained. The infant should also be surrounded by hot-water bottles at its feet and at the sides.

The excessive heat is trying to the nurses, but the natural circulation of air gives to the delicate infant a much better chance of life. Most of the difficulties associated with the abnormal heat of the room are to be surmounted by provisions meeting the necessities. The nurses should abandon ordinary dress, and should be attired in a few light and loose garments. Their changes of duty should be frequent, so that the same nurse is not compelled to remain in the room for more than four hours. Precautions are also necessary to prevent the nurses taking chill from exposure to the external air.

Where it is impracticable to secure a suitably-warmed and adequately-ventilated room an incubator may be used.

In either case, the temperature should not be kept higher than is necessary to maintain a normal temperature in the infant, and as its age increases the external heat supplied should be gradually reduced, so that the production of animal heat and of vigour is stimulated.

Alcohol is of the greatest value during the first days or weeks of the life of a premature infant. It is usually most efficacious when given in 3 or 5 minim doses (in a teaspoonful of warm water) immediately before feedings,

The Feeding of Premature Infants.—Both in regard to fat and proteins the digestion is extremely weak, and consequently the milk mixture needs to be extremely dilute. The feedings require to be frequent, and the amount at each feed should not at first exceed 1 drachm. The following mixtures illustrate the general character of the food required, the precise composition of the mixture being dependent on the age and condition of the infant :

	Per Cent.	Per Cent.	Per Cent.
℞ Fat	1·00	1·00	1·25
Lactose	3·50	4·00	4·50
Whey proteins	0·25	0·50	0·50
Caseinogen	0·10	0·10	0·25
Lime-water	5·00	5·00	5·00
	24 feeds, each of 1 dr.	24 feeds, each of 1 dr.	12 feeds, each of 2 dr.

As a rule the infant is too feeble to suck, and is generally fed by means of a spoon or medicine-measure. These, however, are not satisfactory, as much of the mixture is spilt. The most convenient form of feeder is a dropper fitted with an indiarubber bulb, such as is used for eye lotions. The food can then be injected into the mouth of the infant, and by this simple expedient much delay and difficulty is saved.

The room which the infant occupies should have a sunny aspect, but the infant itself should be protected from direct light and kept in semi-darkness. The prognosis in regard to premature infants should always be extremely guarded until continuous progress has been made for some time. The vitality is so weak that, despite the utmost care and vigilance, collapse and death are liable to occur. Almost invariably, early deaths are associated with atelectasis or with secondary collapse of the lungs. The most important factor in regard to prognosis is the length of the infant. An infant under 19 inches in length will not live, as a rule, more than a few weeks. If it is one of twins, the prognosis is slightly more favourable.

The Diet of Later Infancy.

Towards the close of the first year of life, functions are established which are indicative of the infant's first stage of development towards the conditions characteristic of the adult, and in consequence the nature of the diet requires to be adjusted to meet the nutritional need.

The changes should at first be made gradually, so as to avoid digestive disturbance by the sudden alteration of the food. In the latter part of the second year the development of the functions is so rapid in a healthy infant that somewhat radical additions to the dietary become necessary.

While the food at this stage of development does not, as a rule, call for the delicate adjustment so essential when the feeding is in substitution for human milk, it is important that special regard be paid to its general character, so that it is nutritious, is given in suitable form, and, particularly, that injurious materials are rigidly excluded.

Starch.—At about the end of the tenth month, and somewhat earlier in cases of exceptional development, starch in suitable form may be added to the food. The oat-jelly[1] recommended by Rotch is useful for this purpose, as the starch is in a delicate form, and the amount to be given can be easily regulated. The following prescription is occasionally used by the author as the means of first introducing starch into the diet:

		Per Cent.
℞	Fat	4·00
	Lactose	7·00
	Proteins	2·25
	Alkalinity	5·00
	Oat-jelly	1 oz.

Six feeds, each of 9 ozs.

[1] Oat-jelly is prepared as follows: Two ounces of coarse oatmeal are allowed to soak in a quart of cold water for twelve hours. The mixture is then boiled down so as to make a pint, and is strained through a fine cloth while it is hot. When it cools a jelly is formed, which is to be kept on ice until needed.

As, in such a mixture, the amount of oat-jelly replaces that amount of added water, the percentage composition of the other elements remains practically the same. When this or a similar mixture is taken well, the amount of starch can be increased, and the composition of the milk can be gradually adjusted to that of whole cow's milk.

Diet in the Second Year.—At the end of the first year bottle-feeding should be abandoned, and bread may be introduced into the diet together with mutton or chicken broth and similar preparations. The form of sugar no longer needs to be confined to lactose, and cane-sugar may replace this. The number of meals should be limited to five, and should be arranged somewhat as follows:

8 a.m.: Bread and milk, prepared from stale bread and whole cow's milk, and sweetened with cane-sugar.

11.30 a.m.: Milk and oat-jelly in equal parts flavoured with a little salt.

1.30 p.m.: Bread with mutton broth, or with gravy pressed from the joint, or with raw-meat juice suitably flavoured. A little mashed potato may be added, but unless the infant is well developed it is wise to postpone this for a month or two.

Evening or late afternoon: Bread and milk.

Raw-Meat Juice.—Raw-meat juice is an extremely valuable method of providing the infant with nourishing and invigorating food. It should be given two or three times in the week, and may be prepared as follows:

Fresh, well-minced steak is mixed with cold water in the proportion of one part of steak to one part of water, and this is vigorously stirred in order to thoroughly break up the muscle fibres. The mixture, after being allowed to stand for thirty minutes covered up in a cool place, should then be strained through muslin in order to exclude all solid material. This fluid may take the place of the broth or gravy referred to, and if the infant shows distaste for the flavour, a small quantity of one of the meat essences

(such as Liebig's) may be added. The juice may be suitably warmed, but should not be raised to a high temperature; otherwise the proteins are coagulated, and in this condition they are much less digestible.

At the end of the fifteenth month milk puddings, bread-and-butter, potatoes (well baked), may be added to the dietary. The juices of fruits such as oranges, peaches, apricots, and strawberries, are also useful. These are best given in the morning about an hour before the second meal. The juice should be carefully strained so that it is entirely free from pulp or seed.

At eighteen months of age, practically all the simple natural foods are permissible. A quite fresh egg beaten up in milk (whole or diluted) forms an excellent meal with bread or toast. Fish in the shape of plaice, sole or cod, carefully freed from bones and without sauce, soups made from meat and vegetables, chicken, beef and mutton, may all be given. The solid foods must be carefully minced, and may be, with advantage, supplemented by mashed potato, bread and gravy.

Stewed apples and fruit jellies are also useful. It is generally advisable to vary the diet from day to day, in order to prevent the infant forming a dislike for certain articles. All forms of pastry, suet puddings, and the like, must be strictly forbidden. They not only tend to upset the digestion, but create a perverse appetite, from which arises a distaste for the foods most valuable in promoting health and vigour. Throughout the period of active growth fat is an important element in the diet.

CHAPTER V

ARTIFICIAL FEEDING

A VERY large number of patent foods for infants are put forward by manufacturers and are described as the best for infants, the most perfect substitute for human milk, or in similar language, and they are most extensively used. In some cases, they appear to be allowed or recommended by members of the medical profession. It therefore becomes necessary to discuss the relative merits of these preparations, though, as they are so extremely numerous, only a few of the more prominent ones can be dealt with. Those not specifically referred to may be regarded as belonging to one of the groups described below.

Milk Foods.—These foods are all made on a method essentially the same, and include such foods as Carnrick's Soluble Food, Manhu Infant Food, Nestlé's Milk Food, and many others. They are generally prepared from milk condensed, sweetened, and then evaporated to dryness, with the addition of some form of flour partly converted into dextrine.

Of these foods, *Nestlé's Milk Food* ('Milo') is probably the most widely known and extensively advertised. Its percentage composition is stated by the manufacturers to be as follows:

Water.	Protein.	Fat.	Carbohydrates.	Mineral Matter.
3·65	14·02	5·26	75·12	1·95

It is advertised as an entire diet for infants, without requiring the addition of milk, and for use 1 ounce is to be mixed with 5 ounces of water.

This preparation is a typical instance of its class, and its defects are so numerous that only the chief points can be given attention. The noxious carbohydrates, in the form of maltose, dextrine, cane-sugar, and starch, constitute the bulk of the mixture. These foods all show a great excess of carbohydrates, while they are extremely deficient in the requisite food materials. When the 'food' is mixed with water, according to the directions, the fat amounts to less than 1 per cent.

Allenbury's Food (*No.* 1).—This is a desiccated cow's milk from which the excess of casein has been removed and some soluble *vegetable* albumin, milk-sugar and cream added. No starch appears to be present. Its percentage composition is—

Water.	Protein.	Fat.	Carbohydrates.	Mineral Matter.
5·7	9·7	14·0	66·85	3·75

For an infant of three months, ½ ounce is to be added to 3 ounces of water. The same excess of carbohydrates is to be noted (though in this case starch is absent), and the fat is deficient.

There are very many objections to the preparation, but, when compared with the very low standard necessarily occupied by dried preparations, this seems to be the most adequate, since it is free from pernicious foreign matter, such as starch, while it contains a comparatively high (though still deficient) percentage of fat. Its use can only be justified when neither fresh milk nor good condensed milk can be obtained. In very exceptional circumstances, the use of some dried preparation may be unavoidable. In such cases this form may be recommended as probably the least harmful.

Horlick's Malted Milk is a mixture of desiccated milk

(50 per cent.), wheat flour (26·25 per cent.), barley malt (23 per cent.), and bicarbonate of soda (0·75 per cent.). Its percentage composition is—

Water.	Protein.	Fat.	Carbohydrates.	Mineral Matter.
3·7	13·8	9·0	76·8	2·70

There is no starch, but a very large proportion of the carbohydrates consists of maltose—a highly undesirable feature. When mixed with water in the proportion of three teaspoonfuls to 4 ounces, the proportion of fat is very deficient. The proteins are also very deficient.

Mellin's Food is prepared from barley and wheat flour, which is converted by diastase into soluble carbohydrates, of which more than half is glucose. It is, practically, little more than sugar in various forms, there being, however, no lactose present. Its percentage composition is—

Water.	Protein.	Fat.	Carbohydrates.	Mineral Matter.
6·3	7·9	*a trace*	82·0	3·8

It differs entirely from the previous preparations in being intended by the manufacturers merely as an adjuvant to milk. For an infant under three months the mixture recommended is half a tablespoonful to $\frac{1}{4}$ pint of milk and $\frac{1}{4}$ pint of water. The manufacturers publish several tables for 'modifying' milk by the use of cream, milk, and the 'food.' Inasmuch as all the good features of these mixtures arise from the milk and cream, and the objectionable features from the presence of the food, these modifications have little to recommend them. Where fresh milk and cream are obtainable, it is entirely unnecessary to use this or any other food.

Owing to the great quantity of carbohydrates, this food when mixed with milk is highly fattening, and an infant fed on the mixture is likely to be abnormally fat and flabby, and to show marked signs of rickets and other nutritional disorders. In connection with preparations of

this kind, it must be remembered that in use the instructions are apt to be disregarded, and very little or no milk given in the mixture. In such cases, the danger is extreme, and the manufacturers can scarcely be held innocent when they give the name of 'food' to a preparation which is manifestly nothing of the kind.

A very large number of foods are prepared from cereals, and contain malt and pancreatic ferments which convert the starch into soluble substances, dextrine or malt-sugar, when mixed, though, as a rule, a large amount of unchanged starch is present. These are intended to be mixed with cow's milk and water. None of them can be recommended. In some cases peptonization of the protein materials has been resorted to. These preparations are the most dangerous of all, since they directly encourage atrophy of the digestive glands.

A further series consists of farinaceous foods in which no alteration has been made in the starch. Since the amylolytic function is not definitely established until towards the end of the first year of life, the fact that these preparations contain starch renders them entirely unsuitable for infants under the age of nine months; while, when farinaceous food is required, it is certainly preferable that it should be supplied in the form of rusks and the numerous simple preparations, such as oat-jelly, bread-jelly, bread, nursery biscuits, and the like.

Condensed Milk.—Condensed milk is cow's milk from which a large proportion of the water has been removed by evaporation, by means of heat under a pressure less than that of the normal atmosphere. The milk is generally reduced to one-third of its original volume, so that only two parts of water require to be added to one part of the condensed milk to restore it to its original composition. Under the term 'condensed milk' are embraced products differing very widely in their composition, these variations being dependent on the charac-

ter of the milk employed and the presence or absence of cane-sugar. A great number of the condensed milks are made from milk from which the fat has been previously abstracted. Dyer[1] reported on the constituents of seventeen samples, some of which were prepared from milk completely skimmed, while others were prepared from partially skimmed milk:

PERCENTAGE OF FAT IN CERTAIN BRANDS OF CONDENSED MILK.

1. Marguerite brand	0·42	10. Clipper brand	0·73
2. Tea brand	0·48	11. Shamrock brand	0·79
3. Gondola brand	0·48	12. Cross brand	0·96
4. Cup brand	0·49	13. Home brand	1·02
5. Goat brand	0·56	14. Handy brand	1·49
6. Calf brand	0·60	15. Nutrient brand	2·36
7. Wheatsheaf brand	0·62	16. Cow brand	2·84
8. Swiss Dairy brand	0·63	17. As You Like It brand	4·23
9. Daisy brand	0·69		

All such preparations may immediately be dismissed as impossible for the purposes of infant nutrition.

Of the condensed milks made from whole milk there are two varieties—the sweetened and the unsweetened. The following table shows the composition of some of the chief brands of *condensed whole milk* (*sweetened*):

COMPOSITION OF CONDENSED WHOLE MILK (SWEETENED).

Brand.	Total Solids.	Proteins.	Fat.	Lactose.	Cane-Sugar.
Nestlé	77·2	9·7	13·7	15·0	37·2
Rose	76·6	8·3	12·4	17·6	36·1
Milkmaid	76·3	9·7	11·0	14·6	38·7
Full Weight	76·5	12·3	11·0	13·5	37·2
Anglo-Swiss	74·4	8·8	10·8	16·0	37·1

The added cane-sugar is a very great defect. Not only is the cane-sugar itself inimical to the infant, but the great sweetness precludes the milk being modified so as

[1] *British Medical Journal*, July 27, 1895.

to result in the mixture containing anything approaching to the normal proportions of fat and albuminoids.

Dilution of Condensed Milk.—To restore the milk to normal, so far as the fat and proteins are concerned, only two parts of water to one of milk would be required. But dilutions as weak as one of milk to fourteen of water are recommended, in order to counteract the excessive sweetness.

Unsweetened Condensed Milk.—The unsweetened condensed whole-cream milks constitute a very much better form of nourishment for the infant, though when sufficiently diluted they are still deficient in fat. The sugar in these is entirely milk-sugar. The following table shows their percentage composition:

Brand.	Total Solids.	Protein.	Fat.	Milk-Sugar.
Ideal - -	38·0	8·3	12·4	16·0
First Swiss -	36·7	9·7	10·5	14·2
Viking - -	34·2	9·0	10·0	13·3
Hollandia -	43·0	11·3	9·8	18·5

The above facts illustrate the most important points in regard to the artificial preparations. They all fail so absolutely in the primal requirements that it is unnecessary to do more than mention a few of the numerous fallacies in connection with this matter.

Proteins.—The term 'protein' is little more than a generic name for a class of natural products, all resembling each other in being nitrogen-containing bodies, but differing very widely in other respects. In regard to the feeding of infants, it is quite illegitimate for us to use such a wide term without limitation. Two albuminoids, practically, only concern us—the whey proteins (chiefly lactalbumin) and caseinogen. The proteins derived from wheat, from the peanut, or from numerous other sources, are quite inadmissible.

Carbohydrates.—In reference to the carbohydrates, these include materials widely differing from each other. The only criterion by which a milk preparation for infants is to be judged in regard to carbohydrate is the presence or absence of lactose. Any other form of carbohydrate is a foreign body.

In the light of our present knowledge the use of these substitutes for milk is deplorable, as it is one of the greatest factors in the excessive mortality and disease among infants. However greatly various authorities may differ as to the most expedient method of providing the infant with an adequate substitute for human milk, all of them are united in their condemnation of these dried and condensed preparations.

In reference to the artificial foods, the two quotations following represent the opinions of independent observers, and may be accepted as indicative of the general conclusions of all authorities:

'There are two diseases—rickets and scurvy—which have so frequently followed their prolonged use, that there can be no escaping the conclusion that they were the active cause. This is the unanimous verdict of all physicians whose experience entitles them to speak with authority upon the subject of infant feeding' (Emmett Holt).

'Clinical observation has proved, however, that a prolonged exclusive diet of condensed milk often results in the development of such nutritional disorders as anæmia, rickets, scurvy, and athrepsia. Moreover, the infant, while apparently healthy, lacks vital resistance, and easily succumbs to the various infectious diseases which he may contract' (Judson and Gittings).

With the constitution of these proprietary foods before us, and the practically unanimous verdict upon them from observers in all countries, it would seem unnecessary to say more.

But the fact remains that thousands of infants die each year in this country, and an inestimable number suffer from disease and deformity, which leave their traces throughout life, as a result of artificial feeding. This matter is therefore of urgent importance.

Among the poorer classes the use of condensed milk for the purpose of infant feeding is widespread, and it is almost invariably the sweetened brands that are used. But it should be remembered that this is largely the result of the absolute failure of our present system.

It is, from the author's experience at the Infants Hospital, comparatively rare to find that the mother has from the first made use of condensed milk. In the great majority of cases cow's milk diluted with water or with barley-water has been tried, and has been rejected in consequence of the dire results. The combined effect of the impure milk and the altogether inadequate modification compels her to resort to what is frequently the only practicable and convenient method of providing her infant with a mixture that it can retain without immediately disastrous consequences.

The great factor in the use of proprietary foods and condensed milk is their fatal facility for use. However simple the domestic modification of cow's milk may be, it implies the daily supply of milk and many tiresome precautions. On the other hand, the mother is assured by label and advertisement that this or that preparation has only to be added to water in a certain proportion to provide a perfect food for the infant.

The 'digestibility' of some of these preparations is not to be denied. Young infants often take them very much better than they do the inaccurate modifications of cow's milk. For this there are two reasons. In the dried foods and condensed milks the processes of preparation cause the curd of the caseinogen to be precipitated in a finer state than that of ordinary cow's milk. But the great

cause of their digestibility is the extremely small amount of food that they contain.

The soluble carbohydrates are usually in great excess, but the materials essential for physiological nutrition are invariably deficient. The infant's incapability of digesting the unmodified protein of cow's milk renders it necessary to adopt measures by which it receives all the essential food elements in their proper character and proportion. The infant-food manufacturer eludes the problem by providing a 'food' which taxes the digestion of the infant but little, for the reason that the amount of material requiring to be digested is so small. The danger of these foods is the greater because the disorders arising from defective feeding, while apparent to the skilled observer, for a long time escape the eye of the mother or attendant responsible for the care of the young infant.

So long as the infant is 'satisfied,' little attention is paid to the general absence of the signs of health. The onset of disease is extremely insidious, and the anæmia, rickets, and scurvy, only slowly develop. Many of these infants never live for a period of time sufficient to allow of the development of specific disease. They are pallid, flabby, listless. Some slight intestinal derangement, arising from, perhaps, a dose of castor-oil or from an excess of indigestible food, occurs. Convulsions ensue; the fits increase in frequency and severity; the infant has no power of rallying, and the most persevering treatment fails to gain any response, so that in the space of twenty-four hours, or less, the infant is dead. Or, perhaps, it is attacked by bronchitis or by one of the specific infective diseases. Death ensues almost before the disease has had time to establish itself. This *want of resistance* is the index of improper feeding and imperfect nutrition.

CHAPTER VI

THE MILK-SUPPLY

DESPITE the great advances in sanitation throughout this country, it is a remarkable fact that the general milk traffic is carried on by methods which are opposed to the first principles of cleanliness.

No product calls for greater precautions in regard to all the details of its handling than milk, and the present system is characterized by an almost complete absence of the measures absolutely necessary to ensure a pure supply.

Conditions of the Milk-Supply.—In London it is possible to obtain pure, fresh milk, supplied under proper conditions—that is, in sealed bottles. But the milk at present thus supplied constitutes an almost negligible fraction of the total supply. The milk-supply of London is drawn from the surrounding country within a radius considerably exceeding one hundred miles. Soon after the cows are milked, care is taken in some cases to cool the milk by the use of some form of apparatus. This cooling undoubtedly retards bacterial growth, but it is seldom carried out at all efficiently. Ice or refrigerating machinery is seldom used, and the temperature of the cooled milk depends upon the temperature of the water supplied at the farm. Thus, the milk seldom falls to a temperature as low as 60° F., except possibly in cold weather, while the precautions taken to keep the milk cool after this preliminary treatment are conspicuous by

their absence. In the hot weather, owing to the high temperature of the water, the 'cooling' is quite ineffective.

Recent developments on the part of milk-vendors have been retrogressive. It has now become a comparatively common practice to *pasteurize* milk, so that the consumer does not obtain the natural article, but a cooked milk. With a perverse ingenuity, refrigerating machinery is employed to remove the heat from the milk so pasteurized, instead of being employed to refrigerate the milk as it comes from the cow.

It cannot be too strongly insisted upon that a milk-vendor who pasteurizes his milk pronounces his own condemnation. Pasteurization enables him to neglect all the essential precautions, so that he can buy the cheapest and dirtiest milk in the market. The price obtained by the farmers for this milk is often as low as 6d. per gallon. The vendors charge for this, when pasteurized, not less than 4d. per quart, the difference in price representing their share of the profits as a return for the modern hygienic precautions which figure so largely in their advertisements. It is necessary to insist that milk should be supplied in its pure and natural condition, and the legal enactments should be of such a character as to effectively protect the public.

When we come to examine in detail the process of the production, collection and delivery of cow's milk, the conditions are found to be so hopelessly bad, the ignorance and carelessness displayed on all sides are so extensive, that no serious improvement is possible without a complete revolution of the whole system.

Insanitation.—The state of affairs at the average farm where milch cows are kept is exceptionally filthy. The cow-house is dirty; in the great majority of cases it is insanitary in the extreme. In respect of drainage and ventilation, the arrangements in many cases could scarcely be worse. Everything is pervaded with cow-dung, urine,

dirty fodder, etc. The cows themselves are covered with filth, dried dung being its chief constituent. It need hardly be said that, under such conditions, the cows appear to be far from healthy; they seem, in general, to look ill and out of condition It is scarcely matter for wonder that tuberculosis is rife, and that this is one of the scourges of farms.

The diet of the cows is characterized by the exclusion of wholesome food, and by the substitution for it of brewer's grains, oil-cake, and other products having a definitely prejudicial effect on the milk.

Contamination.—In November, 1903, Dr George Newman, Medical Officer of Health for Finsbury, published an elaborate report[1] on the conditions of the milk-supply in that borough, and the facts there collected may be regarded as fairly typical of the conditions generally prevailing. He found that 90 per cent. of the milk was obtained from country farms, and that 95 per cent. of these were situated at a greater distance than 100 miles from London. As a rule the evidence showed that the cow-sheds from which the milk was derived were ill-lit, over-crowded, badly ventilated and badly drained. Of the milk-shops, 52 per cent. were found to have one or more sanitary defects, and 73 per cent. of the vendors failed to keep the milk covered or protected from dust. The average number of bacteria in unpreserved milk was found to be 2,370,000 per cubic centimetre. Pus and dirt were found in a large number of cases.

Infectious Diseases.—The part played by milk in regard to infectious disease is demonstrated by the facts collected by Kober.[2] In 1900 he collected the records of 330 outbreaks due to the agency of milk. There were 195 outbreaks of typhoid fever, 99 of scarlatina, and 36 of

[1] Report on the milk-supply of Finsbury, 1903.

[2] *American Journal of the Medical Sciences*, May, 1901.

diphtheria. In the typhoid epidemics the infection was traced to the dairy in 148 instances. In 67 the well-water was infected; in 7 the cows probably waded in infected water; in 24 cases the employees acted as nurses, and in 10 they continued at work although themselves suffering from the disease. In 1 case the milk-pans were washed with cloths used about patients; in 2 cases the dairy employees were connected with the night-soil service; and in 1 case the milk had been kept in a closet in the sick-room.

Of the 99 epidemics of scarlatina, the disease occurred at the farm or dairy in 68 cases. In 17 cases the employees were affected, and in 10 cases they acted as nurses. In 6 cases persons connected with the dairy lodged in or visited infected houses, in 2 cases empty cans or bottles were brought from infected houses; in 3 cases the milk was stored in or near an infected room; and in 1 case the utensils were wiped with a contaminated cloth.

The question of scarlatinal infection is complicated by the question whether cows themselves suffer from the disease or from a disease associated with the organism giving rise to scarlatina in the child. In 1885 Sir William Power adduced evidence to show that the scarlet fever occurring in persons consuming milk from a farm at Hendon was of bovine origin, the cows being affected with an eruption of the teats and udder. It would appear to be established that there is a condition in cows closely allied to puerperal fever, and the milk from these cows can convey the infection of scarlatina. The disease is one always associated with newly calved cows.[1]

It need hardly be said that, with proper regulations at the farm, the milk from such cows would be immediately rejected, the cows being isolated. At the farm supplying

[1] *Vide* report to the London County Council by Dr. W. H. Hamer and Dr. T. Henry Jones on an outbreak of scarlet fever occurring in June, 1909, in London and Surrey.

the Infants Hospital farm any cow suffering from an affection of the udder is immediately isolated.

Of the 36 epidemics of diphtheria, in 13 cases the disease occurred at the farm or dairy. In 3 cases the employees themselves were suffering ; in 12 cases the disease was apparently traced to a cow which suffered from disease of the udder.

A striking instance of the part played by milk in the spread of infection has been furnished by Dr. R. W. C. Pierce,[1] Medical Officer of Health for Guildford and Woking R.D.C. Numerous cases of epidemic sore throat, accompanied in several instances by enlarged glands and abscesses, occurred. Severe constitutional disturbance manifested itself, with fever and various other symptoms. Several cases developed erysipelas of the face and neck.

Information was obtained in regard to 98 infected houses, and out of this number 76 were directly supplied with milk which proved to be the cause.

The source of infection was traced to a certain farm. Of four cows examined, from the first cow dirty pinkish milk was obtained from one teat, and from the second cow pinkish, thick, curdy matter was obtained from two teats. The facts in regard to the other cows were very similar, and Dr. Pierce stated that the liquid yielded by two of the cows consisted for the most part of pus, such as would be contained in an abscess.

Bacterial Development.—The rapid development of bacteria in milk that is improperly handled is illustrated by the tables of Miquel and Backhaus. Holt quotes two striking instances illustrating the importance of proper precautions. The observations were made at the laboratory of the New York Health Department.

[1] *British Medical Journal*, December 5, 1903.

	Bacteria.
A sample of milk taken under good conditions contained, immediately after milking, in each drop - - -	300
It was cooled to 45° F., and kept at this temperature.	
After twenty-four hours it contained in each drop -	200
After forty-eight hours " " " -	900
After seventy-two hours " " " -	150,000
Another sample, taken in a dirty barn, cooled and kept at 52° F., contained, at first, in each drop - - -	2,000
After twenty-four hours it contained in each drop -	6,000
After forty-eight hours " " " -	245,000
After seventy-two hours " " " -	16,500,000

The factors of bacterial development, in regard to the purity of milk, demand special consideration, and the chief facts in regard to this are discussed in Chapter VIII.

Medical Commissions.—The observations of various workers in different countries demonstrate the fact that the milk supplied is, in general, quite unfit for use. It becomes, therefore, an absolute necessity to lay down the principles and rules which must govern the handling of milk. In America, great strides have been made in the solution of this problem. Medical Commissions have been established whose business it is to supervise the milk traffic, and to append their certificate to milk produced and handled in a manner in accordance with their requirements.

Whether the process of certification in this country would be equally successful is, under the present circumstances, open to much doubt. The whole value of a certificate depends upon the authority of those signing it. While one company might gain a fully-deserved certificate from an independent authority, it would be open to any dairy company to obtain a certificate of some sort or another, which, however valueless from a scientific point of view, might, at any rate, do much to mislead the public.

Further, it would be easy for a milk company to obtain a specimen of milk under the strictest precautions, and to submit this specimen so obtained for examination.

The resulting certificate would, of course, only be applicable to the actual specimen submitted; but, having regard to the ignorance of the public, and the general attitude of the milk companies, it is by no means improbable that such a certificate would be made use of in reference to milk of a totally different character.

Whatever methods may prove to be the most practicable, it is a matter of imperative importance that the disgraceful conditions of the general milk-supply of this country should be ended. No trivial improvements or alterations of a minor character can effect this. Radical changes are required in everything concerned with the handling of the milk from the time it leaves the cow to the time it reaches the consumer.

The following circular, which is issued by the New York Commission, explains itself and presents a concise summary of the precautions necessary to be adopted in the regulation of the milk traffic.

Circular of Information concerning the Requirements of the Milk Commission of the Medical Society of the County of New York for 'Certified Milk.'

The Commission appointed by the Medical Society of the County of New York to aid in improving the milk-supply of New York City invites the co-operation of the milk-dealers and farmers in attaining that end. The sale of pure milk is of advantage to those furnishing it, as well as to those who use it. The Commission has undertaken to assist both consumer and producer by fixing a standard of cleanliness and of quality to which it can certify, and by giving information concerning the measures needful for obtaining that degree of purity.

The most practicable standard for the estimation of cleanliness in the handling and care of milk is its relative freedom from bacteria. The Commission has tentatively fixed upon a maximum of 30,000 germs of all kinds per cubic centimetre of milk, which must not be exceeded in order to obtain the endorsement of the Commission. This standard must be attained solely by measures directed towards scrupulous cleanliness, proper cooling, and prompt delivery. The milk certified by the Commission must contain not less than 4 per

cent. of butter fat on the average, and have all other characteristics of pure, wholesome milk.

In order that dealers who incur the expense and take the precautions necessary to furnish a truly clean and wholesome milk may have some suitable means of bringing these facts before the public, the Commission offers them the right to use caps on their milk-jars stamped with the words 'Certified by the Commission of the Medical Society of the County of New York.' The dealers are given the right to use these certificates when their milk is obtained under the conditions required by the Commission and conforming to its standards.

The required conditions are as follows :

1. THE BARNYARD.—The barnyard should be free from manure and well drained, so that it may not harbour stagnant water. The manure which collects each day should not be piled close to the barn, but should be taken several hundred feet away. If these rules are observed, not only will the barnyard be free from objectionable smell, which is always an injury to the milk, but the number of flies will be considerably diminished. These flies in themselves are an element of danger, for they are fond of both filth and milk, and are liable to get into the milk after having soiled their bodies and legs in recently visited filth, thus carrying it into the milk. Flies also irritate cows, and by making them nervous reduce the amount of their milk.

2. THE STABLE.—In the stable the principles of cleanliness must be strictly observed. The room in which the cows are milked should have no storage loft above it ; where this is not feasible, the floor of the loft should be tight, to prevent the sifting of dust into the stable beneath. The stable should be well ventilated, lighted, and drained, and should have light floors, preferably of cement. They should be whitewashed inside at least twice a year, and the air should always be fresh and without bad odour. A sufficient number of lanterns should be provided to enable the necessary work to be properly done during dark hours. There should be an adequate water-supply and the necessary wash-basins, soap, and towels. The manure should be removed from the stalls twice daily, except when the cows are outside in the fields the entire time between the morning and afternoon milkings. The manure gutter must be kept in a sanitary condition, and all sweeping and cleaning must be finished at least twenty minutes before milking, so that at that time the air may be free from dust.

3. WATER-SUPPLY.—The whole premises used for dairy purposes, as well as the barn, must have a supply of water absolutely free from any danger of pollution with animal matter, and sufficiently abundant for all purposes and easy of access.

4. THE COWS.—The cows should be examined at least twice a year by a skilled veterinarian. Any animal suspected of being in bad health must be promptly removed from the herd, and her milk rejected. Never add an animal to the herd until it has been tested with tuberculin, and it is certain that it is free from disease. Do not allow the cows to be excited by hard driving, abuse, loud talking, or any unnecessary disturbance. Do not allow any strongly-flavoured food, like garlic, which will affect the flavour of the milk, to be eaten by the cows.

Groom the entire body of the cow daily. Before each milking wipe the udder with a clean damp cloth, and when necessary wash it with soap and clean water, and wipe it dry with a clean towel. Never leave the udder wet, and be sure the water and towel used are clean. If the hair in the region of the udder is long and not easily kept clean, it should be clipped. The cows must not be allowed to lie down after being cleaned for milking until the milking is finished. A chain or rope must be stretched under the neck to prevent this.

All milk from cows sixty days before and ten days after calving must be rejected.

5. THE MILKERS.—The milker should be personally clean. He should neither have nor come in contact with any contagious disease while employed in milking or handling milk. In case of any illness in the person or family of any employee in the dairy, such employee must absent himself from the dairy until a physician certifies that it is safe for him to return.

Before milking, the hands should be thoroughly washed in warm water with soap and a nail-brush, and well dried with a clean towel. On no account should the hands be wet during the milking.

The milking should be done regularly at the same hour morning and evening, and in a quiet, thorough manner. Light-coloured washable outer garments should be worn during milking. They should be clean and dry, and when not in use for this purpose should be kept in a clean place protected from dust. Milking-stools must be kept clean. Iron stools, painted white, are recommended.

6. HELPERS OTHER THAN MILKERS.—All persons engaged in the stable and dairy should be reliable and intelligent. Children under twelve years should not be allowed in the stable during milking, since in their ignorance they may do harm, and from their liability to contagious diseases they are more apt than older persons to transmit them through the milk.

7. SMALL ANIMALS.—Cats and dogs must be excluded from the stables during the time of milking.

8. The Milk.—The first few streams from each teat should be discarded, in order to free the milk-ducts from milk that has remained in them for some time, and in which bacteria are sure to have multiplied greatly. If in any milking a part of the milk is bloody or stringy, or unnatural in appearance, the whole quantity of milk yielded by that animal must be rejected. If any accident occurs by which the milk in a pail becomes dirty, do not try to remove the dirt by straining, but reject all the milk and cleanse the pail. The milk-pails used should have an opening not exceeding 8 inches in diameter.

Remove the milk of each cow from the stable immediately after it is obtained to a clean room, and strain it through a sterilized strainer.

The rapid cooling of milk is a matter of great importance. The milk should be cooled to 45° F. within one hour. Aeration of pure milk beyond that obtained in milking is unnecessary.

All dairy utensils, including bottles, must be thoroughly cleansed and sterilized. This can be done by first thoroughly rinsing in warm water, then washing with a brush and soap or other alkaline cleansing material and hot water, and thoroughly rinsing. After this cleansing they should be sterilized with boiling water or steam, and then kept inverted in a place free from dust.

9. The Dairy.—The room or rooms where the bottles, milk-pails, strainers, and other utensils, are cleaned and sterilized should be separated somewhat from the house, or, when this is impossible, have at least a separate entrance, and be used only for dairy purposes, so as to lessen the danger of transmitting through the milk contagious diseases which may occur in the home.

Bottles after filling must be closed with sterilized discs and capped, so as to keep all dirt and dust from the inner surface of the neck and mouth of the bottle.

10. Examination of the Milk and Dairy Inspection.—In order that the dealers and the Commission may be kept informed of the character of the milk, specimens taken at random from the day's supply must be sent weekly to the Research Laboratory of the Health Department, where examinations will be made by experts for the Commission, the Health Department having given the use of its laboratories for this purpose.

The Commission reserves to itself the right to make inspections of certified farms at any time, and to take specimens of milk for examination. It also reserves the right to change its standards in any reasonable manner upon due notice being given to the dealers.

Milk Commissions have been established in other cities, such as Baltimore, Buffalo, and Philadelphia. The regulations of the Philadelphia Commission are, in general, of the same character as those above quoted, but in many details they are more explicit and demand fuller precautions. Some of the most important provisions of this Commission are here printed in italics:

'The Commission shall select a bacteriologist, a chemist, and a veterinary inspector. The bacteriologist shall procure a specimen of milk from the dairy, or *preferably from delivery waggons*, at intervals to be arranged between the Commission and the dairy, but in no case at a longer interval than one month. The exact time of the procuring shall be without previous notice to the dairy. He shall test this milk for the *number* and *nature* of bacteria present in it, to the extent which the needs of safe milk demand. He shall also make a microscopic examination of the milk for pus cells. Milk free from pus and injurious germs, and *not having more than* 10,000 *germs of any kind or kinds to the cubic centimetre*, shall be considered to be up to the required standard of purity.

'The chemist shall in a similar manner procure and examine the milk for the *percentage of proteins*, *fat*, *sugar*, *mineral matter*, *and water*, *present*. He shall also test its chemical reaction and specific gravity, and shall examine it for the presence of foreign colouring or other matters or chemicals added as preservatives. Standard milk shall range from 1029 to 1034 specific gravity, be neutral or very faintly acid in reaction, contain not less than from 3·5 to 4·5 per cent. proteins, from 4 to 5 per cent. sugar, and not less than from 3·5 to 4·5 per cent. fat, and shall be *free from all foreign contaminating matter and from all addition of chemical substances or colouring matters*.

'Richness of cream in fat shall be specified, and shall vary not more than 1 per cent. above or below the figures named in selling. Neither milk nor cream shall have been subjected to heat before the examination has been made, nor at any time unless so announced to the consumer.

'The veterinary inspector shall, at intervals equal to those of the bacteriologist and chemist, and without previous warning to the dairy, *inspect the cleanliness of the dairy in general*, the care and cleanliness observed in milking, the care of the various utensils employed, *the nature and quality of the food used*, and all other matters of a hygienic

nature bearing upon the health of the cows and the cleanliness of the milk, including also, as far as possible, an inquiry into the health of the employees on their farms. He shall also see that the cows are free from tuberculosis and other disease.

'. . . Any dairy, the milk of which shall be found by the examiners to be up to the standard of the Commission, shall receive a certificate from the Commission. . . .

'The dealers to whom certificates have been issued shall furnish milk to their customers *in glass bottles hermetically sealed* in a manner satisfactory to the Commission. In addition to the sealing, and as a guarantee to the consumer that the examination has been regularly conducted, there shall be pasted over the mouth of the jar, or handed to the customer with every jar, according to the discretion of the Commission, a certificate. . . .'

These two specifications, taken together, show what is being done in America and what ought to be done in this country.

The regulations of the Philadelphia Commission are in advance of those of New York. In regard to the composition of the milk, the regulation regarding the chemical examination, to determine the presence of the constituents of milk in their proper proportion, is a valuable one; while the number of bacteria per cubic centimetre must not exceed 10,000, and this figure is much fairer to the consumer without pressing unduly upon the farmer. It will also be noticed that the microscopical examinations of the milk for pus cells is a valuable provision. We may therefore regard the regulations of the Philadelphia Commission as the model for other cities and other countries. Nothing but organization on the part of those concerned with the production and sale of milk, and on the part of the medical profession, in this country, is required to ensure that the general milk-supply should be of a character answering to these requirements.

With regard to the question of cost, practical ex-

perience of a properly-managed and properly-equipped farm shows that the provision of a pure milk-supply can be attained without seriously increasing the cost of milk. At the present time the farmer loses heavily by reason of his incompetence. He continually sustains serious commercial losses in consequence of his want of acquaintance with the measures necessary for the care and management of milch cows. It is quite a common occurrence for the farmer to lose a valuable animal as a result of puerperal sepsis arising from the neglect of ordinary sanitary precautions. Absence of anything approaching efficient management is the characteristic feature of the average milk-farm, and with this inefficiency are associated its invariable accompaniments, waste and extravagance. When a farm is properly organized the heavy losses arising from incompetent management disappear, and the farmer recoups himself for the expenses entailed in efficiency by the health of his cows and their increased production of milk. The proof of this is seen at the Infants Hospital. The milk supplied has to comply with the most stringent requirements in regard to quality and purity, and it costs the hospital 25 per cent. less than the ordinary retail price of milk as sold in London.

CHAPTER VII

THE HEATING OF MILK AND THE RESULTING CHANGES

THE dangers attendant upon contaminated milk have been discussed, and the instances quoted form but a fragment of the evidence that could be brought forward from all sides to demonstrate the part played by contaminated milk in the causation of specific infectious diseases and the diseases of the alimentary tract.

The Boiling of Milk.—In consequence of this frequent contamination, various processes of heating milk have been introduced in order to destroy the germs of infection and thus protect infants and others from their effects. These methods have been warmly advocated by many writers, and the boiling or sterilization of milk has almost come to be regarded as a classic practice typical of sanitary advance and medical progress.

At the outset it must be said that, whatever be the excuse of expediency, the whole argument would appear to be unsound and inconsistent with the principles of scientific procedure. To supply an infant with contaminated milk is certainly far from advisable, but milk containing pathogenic bacteria is contaminated whether heated or unheated.

The *prevention* of contamination is the prime necessity. Methods of counteracting the effects of contamination, so far from being regarded as sanitary advances, must be

regarded as temporary expedients, possibly advisable in certain circumstances to avoid worse ills, but necessarily carrying with them the gravest reflection upon a system under which such procedures become advisable.

As the use of boiled or sterilized milk has become more general, the results have been far from what was expected, and the injurious effects are being frequently demonstrated. It is therefore important that the changes produced by the heating of milk should be understood.

Owing to the confusion of terminology that at present exists among writers on the subject, it is necessary to specify as definitely as possible what is meant by the terms 'sterilization,' 'pasteurization,' etc. Sterilization, for instance, is not effected by boiling for thirty minutes, and this term is frequently misapplied.

Effects of Heat on Milk.—Rotch has summarized some of the facts in relation to the action of heat on milk which are of especial importance in reference to the preparation of milk mixtures:

1. Most pathogenic organisms are destroyed at from 140° F. to 147° F. (from 60° C. to 63·9° C.).

2. Certain spores are not destroyed by a single pasteurization.

3. All spores are destroyed at a heat of 248° F. (120° C.).

4. All micro-organisms are destroyed at 154·4° F. (68° C.).

5. The tubercle bacillus has lived in a heat of 149° F. (65° C.) with one hour's exposure.

6. Lactalbumin, the chief constituent of the whey proteins, coagulates at 161·6° F. (72° C.).

7. The rennin enzyme is destroyed at 140° F. (60° C.).

Pasteurization.—On the degree of heat and the time of exposure involved in the term *pasteurization* there appears to be no definite agreement. Holt requires the temperature to be raised to 167° F. (75° C.), and so maintained

for twenty minutes. Freeman names 155° F. (68·3° C.) as the temperature, and thirty minutes as the time of exposure. Leeds names 157° F. (69·4° C.) as the temperature.

The present author, when ordering pasteurization to be carried out, requires the laboratory to heat the milk to 150° F. (65·6° C.) for 10 minutes. *Pasteurization* is, therefore, a somewhat vague term, not definitely connoting either precise length of exposure or precise temperature. The maximum temperature of *pasteurization* must be regarded as 167° F.; and this appears too high, since lactalbumin begins to coagulate at 161·6° F. The minimum may be regarded as 140° F.

Sternberg's table gives the exposure and temperature at which some of the chief micro-organisms succumb:[1]

TEMPERATURE AND EXPOSURE NECESSARY TO DESTROY CERTAIN BACTERIA.

	Temperature.	Exposure.
Bacillus diphtheriæ - - -	58° C. (136° F.)	Ten minutes.
,, *typhosus* - - -	56° C. (133° F.)	,,
Pneumococcus - - - -	52° C. (125° F.)	,,
Bacillus coli communis - -	60° C. (140° F.)	,,
,, *acidi lactici* - -	56° C. (133° F.)	,,
Staphylococcus pyogenes aureus -	58° C. (136° F.)	,,
,, ,, *albus* -	62° C. (144° F.)	,,

Sterilization.—Sterilization of the milk implies that the length of exposure and the degree of heat must be such that all organisms and all spores are completely destroyed. If this is to be effected at one exposure, the heat must be extreme, and above the boiling-point of milk (101° C.). Miquel's figures for the destruction of all germs are: One hour at 105° C. (221° F.), half an hour at 108° C. (226·4° F.), fifteen minutes at 110° C. (230° F.). The author has repeatedly found these temperatures insufficient to obtain absolute sterilization. In his laboratory all milk sterilized for bacteriological purposes is maintained at a

[1] Quoted from Judson and Gittings, *op. cit.*

temperature of 120° C. (248° F.) for twenty minutes. It should be pointed out that this temperature means a much longer exposure to a temperature above boiling-point than twenty minutes. For, as the indicated temperature is only gradually reached and only gradually reduced, the total time-temperature exposure above 100° C. is, approximately: (1) twenty minutes, during which the milk is rising from 100° C. to 120° C; (2) twenty minutes, during which the temperature is automatically maintained constant at 120° C.; (3) twenty minutes, during which the temperature is falling to 100° C. Milk so sterilized is orange-brown in colour.

Another method of sterilization is by heating to 100° C. (212° F.) for thirty minutes, and repeating this on the two following days, thus allowing the uninjured spores to develop into organisms, and be destroyed at the second or third heating.

Objections to Sterilization.—The objections to all methods of sterilization, boiling, or pasteurization fall under two heads: (1) The direct injury to the milk, so that its nutritive value is greatly impaired; (2) the poisonous products produced, owing to the fact that no method of sterilization that can be applied to milk intended to be used as a food is in any way effective in relation to the destruction of organisms. So far from destroying harmful organisms, the cooking of milk means the destruction of organisms of vital importance to the infant, while the putrefactive organisms rapidly develop in the milk after it has been cooked owing to the absence of the lactic organisms.

The chief physical and chemical changes occurring in milk as the result of sterilization, according to various authorities, have been tabulated by Judson and Gittings.[1]

Lecithin and nuclein are decomposed, organic phosphorus is diminished, while the inorganic phosphorus is increased.

[1] *Op cit.*, p. 230.

The phosphates become insoluble, and precipitation of the calcium and magnesium salts occur.

Normal lactic acid fermentation is inhibited.

The fat emulsion is injured or destroyed.

The lactalbumin is coagulated, and caseinogen is only partially or not at all coagulated by rennin, this latter change being related to the precipitation of the calcium salts.

Digestion of the caseinogen is delayed. After prolonged sterilization, albuminoid toxins may be produced.

Richmond[1] states that at about 80° C. (176° F.) certain organized principles, the nature of which is not fully known, undergo a change. The presence of these principles in an unchanged form is demonstrated by certain reactions. They cause an evolution of gas from peroxide of hydrogen in the cold, and give a blue colour with para-phenylene-diamine and hydrogen peroxide.

J. E. Saul[2] published an important observation in relation to the alterations caused by heat. On treating milk with a solution of orthomethylaminophenol sulphate $[(OH).C_6H_4.NHMe]H_2SO_4$, and then adding hydrogen peroxide solution, a very vivid deep-red colour is produced. Milk that has been previously boiled and cooled remains uncoloured, a faint pink only developing on standing. The red colour is so strong and pronounced that so little as 1 per cent. of raw milk, if added to heated milk, may be detected with ease. The test may be applied as follows: To 9 or 10 c.c. of the milk add 1 c.c. of a recently prepared 1 per cent. aqueous solution of orthomethylaminophenol sulphate, and then add one drop of commercial hydrogen peroxide solution. The red colour develops within thirty seconds if there is any raw milk present in the sample. Excess of hydrogen peroxide should not be added, as it tends to weaken and bleach the colour. Dilute acids do

[1] *Op. cit.*, p. 145.

[2] 'Note on the Detection of Raw Milk and Formaldehyde' (*British Medical Journal*, March 21, 1903).

not affect, caustic alkali destroys the colour. The presence in the milk of boric acid, formaldehyde, or sodium bicarbonate, does not interfere with the reaction. If the milk is sour, the acidity should be neutralized before the test is applied. Saul has also determined the temperature at which these principles are destroyed. If milk is kept at 75° C. (167° F.) for thirty minutes, it fails to give the reaction; milk kept at 70° C. (158° F.) for an hour still reacts to the test. He concludes that there is present in milk an oxidizing enzyme destructible by heat. This test has been applied by the author in numerous instances. It is thoroughly reliable and satisfactory. The only points requiring special attention are that the solution of the reagent should be freshly made, and that its strength should not be seriously greater than that prescribed.

An experiment suggested to the author by Sir Lauder Brunton is of interest in this connection.

By means of acetic acid casein was precipitated from (1) a specimen of raw milk, (2) a specimen of boiled milk. The casein so precipitated was in each case washed with a dilute solution of sodium carbonate to remove the acidity, and the washed specimens were thrown into beakers containing a solution of commercial hydrogen peroxide. The casein derived from the raw milk gradually rose to the surface, being lifted by the bubbles of oxygen liberated from the solution. In the case of the specimen derived from the boiled milk no reaction occurred, the casein remaining in a dense mass at the bottom of the beaker.

Whatever may be the chemical explanation, the fact that sterilized milk is responsible for the production of scurvy and other diseases is a well-established fact.

Carstens and Von Starck have both found that the systematic use of sterilized milk leads to grave disturbances of nutrition, resulting in the development of

severe anæmia, rickets, and scurvy. Eighty-four out of 300 medical practitioners in Schleswig-Holstein reported the occurrence of rickets, anæmia, errors of development and other disorders, arising from the use of sterilized milk. Numerous other observers[1] have confirmed these statements. The American Pediatric Society's investigations in regard to the incidence of infantile scurvy showed that 107 cases were due to sterilized milk.[2]

Holt points out that even pasteurization at 167° F. for thirty minutes may result in scurvy. He has seen at least three such cases. In view of Saul's experiments, this clinical observation is especially interesting.

The above facts are sufficient to show that the heating of milk is attended with the greatest danger to nutrition, and that all our efforts should be in the direction of obtaining a pure, clean, and *fresh* milk.

As systematic practices, boiling, pasteurization, and sterilization must be absolutely condemned. When heating appears to be necessary, the temperature should not exceed 150° F. For purely temporary purposes, as, for instance, where the infant is on board ship, and in other exceptional circumstances, pasteurization for a limited period may be advisable. In the case of milk modification, the great value of the divided proteins renders the heating of part of the mixture (the whey) to 140° F. necessary, in order to kill the rennin enzyme. The whey must therefore be heated, but for not longer than three minutes, nor at a higher temperature than 150° F.; the rest of the mixture, the fat-free mixture, etc., should not be heated at all.

In recent years the author has entirely abandoned the use of cooked milk. All infants and children under his care are systematically fed on unheated milk-mixtures, the food being warmed to blood-heat immediately before ad-

[1] *Vide* Judson and Gittings, *op. cit.*

[2] *Vide* Chapter XVII.

ministration, and there has been no exception to this rule for some years.

The boiling of milk is a direct interference with the special protective mechanism of natural processes. Pure unheated milk *never putrefies*. When stood in a vessel for a sufficient period at a favourable temperature, it undergoes a decomposition of a character altogether special and peculiar to milk. Lactic acid is produced, and this acid, which is a normal constituent of the gastric and intestinal contents of the infant, protects the milk from those organisms associated with putrefactive changes, for these cannot grow in an acid medium. In boiled milk the decomposition is entirely different in character: no formation of lactic acid occurs, the decomposition is putrefactive in kind, and the products of this decomposition are highly poisonous in their character. In the etiology of intestinal disorder, of rachitis, and of nearly all ailments from which infants commonly suffer at the present time, cooked milk is one of the most powerful agents. It cannot be otherwise, for the cooking of the food of the infant is a proceeding directly opposed to the chemistry and physiology of the digestive processes.

CHAPTER VIII

THE BACTERIOLOGY OF MILK

The Bacteriological Standard for Milk.—Conn has pointed out certain facts, in relation to the bacteriological examination of milk, which must be appreciated before we form conclusions drawn from bacteriological analysis.

Whereas a sample of water containing a few thousand bacteria per cubic centimetre must be immediately regarded as suspicious, it is certain that a milk containing the same or a greater number of bacteria may be perfectly wholesome. A comparison of the number of bacteria in water and in milk will show, in water, a few hundred per cubic centimetre, and, in milk, many thousands. Even when compared with sewage, from the standpoint of the *number* of bacteria, milk proves to be surprisingly bad. The milk supplied to our cities frequently contains a greater proportion of bacteria than the city's sewage. In the case of unusually bad samples of milk the number of bacteria is in excess of the number found in the worst sewage. On the other hand, the presence of a small number of bacteria does not necessarily prove that the milk is wholesome, for among the small number may be organisms specifically pathogenic—such, for instance, as the *Bacillus typhosus*.

The great number of bacteria so frequently found in milk is due to the fact that it forms one of the finest nutrient media for the growth and development of certain organisms, being far superior in this respect to either water

or sewage. And it is clear that neither the presence nor the number of bacteria in milk can be regarded in at all the same light as in the case of water. Yet, despite these qualifications, the number of bacteria found in milk forms an accurate and reliable guide when properly interpreted.

The Bacteriological Testing of Milk.—With proper precautions in the dairy and in transit, it has been proved that the number of bacteria can be kept within a certain maximum, and thus it is possible to determine by the bacteriological count the character of the methods of procuring and handling the milk. In practice this has proved to be a most satisfactory method. On the one hand, it has pointed out the precautionary measures that are necessary; on the other, it has been a most valuable check, at once calling the attention of those concerned to any defect.

Milk stands out from all other foods by virtue of its liquid condition. It contains within itself all the materials necessary to maintain life and encourage development. Hence it is above all other foods the one most liable to, and most affected by, bacterial contamination. In order to ensure the systematic delivery of pure milk to the consumer, the greatest precautions are necessary in regard to all the details from the cow to the house at which it is delivered. A natural milk absolutely sterile is a practical impossibility. In the mammary gland itself the milk is in all probability entirely free from micro-organisms, but in passing through the udder—which is by no means sterile—milk necessarily comes to contain micro-organisms. Even if this were not so, the obtaining of a sterile milk would be an advantage of a purely theoretical character. In the mouth of both infant and adult hosts of organisms exist, so that the sterile food becomes the reverse immediately it is taken.

Bacteria in Stomach and Intestine.—The infant's stomach usually contains from 4,000 to 240,000 bacteria

per cubic centimetre. In infants nursed at the breast the number present in the stomach has been ascertained to be from 7,000 to 20,000 per cubic centimetre.[1]

The infant may be fed on absolutely sterile food without in any way diminishing the bacteria present in the stomach and intestine; indeed, the adminstration of a sterile food generally results in the increase of the bacteria present in the alimentary canal, and in alterations of their character. Eberle[2] examined bacteriologically the fresh fæces of an infant fed on sterilized food. In 1 milligramme he found 33,000,000 organisms.

The Storage of Milk.—In storing milk we are making a wide departure from nature, and it is consequently necessary to counteract the effects of the artificial condition by measures calculated to absolutely prevent the growth of bacteria and the production of bacterial toxins. At 40° F. the bacterial development is practically nil; the bacteria originally present in the milk still exist, but they cannot develop to any serious extent.

The secretion of the mammary gland of the cow was, of course, intended for the nourishment of its offspring, and thus the food was transferred directly from the mammary gland of the mother to the stomach of the calf. Hence no external *development* of bacteria could occur.

In the course of a long evolution, altogether unique in its wide departure from the primitive natural state, the mammary gland of the cow has been so greatly diverted as to become the source of one of our primal food-supplies. Moreover, as civilization has advanced and large towns have been formed, the problem has become more and more complex. The food intended for immediate consumption has been placed at greater and greater distances from the consumer, so that the milk-supply of any

[1] Langermann, *Jahrbuch für Kinderheilkunde*, Bd. xxxv., 1893.

[2] 'Zählung der Bakterien im normalen Säuglingskot' (*Centralblatt für Bakteriologie und Parasitenkunde*, Bd. xix., 1896).

great city is derived from the country around within an extremely wide radius.

Bacteria present in Pure Milk.—From the considerations already mentioned, it may be said that a large number of the micro-organisms present in good fresh milk are quite harmless; while certain of these organisms are absolutely necessary to the infant.

Milk collected and handled with the most complete precautions always contains numerous bacteria. The milk of the Chestnut Hill Farm of the Philadelphia Laboratory was examined for 354 days in the Pepper Laboratory of the University of Pennsylvania. These examinations showed an average of 2,550 bacteria per cubic centimetre. There were only twenty days when the average was over 10,000. The lowest average number of bacteria was 1,150 per cubic centimetre.[1]

Were all milk as free as this, the infant fed on it must receive millions of bacteria into its stomach. This is sufficient to demonstrate the absolute harmlessness of bacteria normal to milk when present in moderate number, for if these micro-organisms really exerted any noxious influence it must inevitably happen, both from their number and their constant presence, that the death of the infant could only be a question of time. At least, their influence on the infant must be neutral, while it would seem that they must possess some beneficial action. For it is almost inconceivable that the natural development of the perfect food for the offspring should be marred by organisms which are as certainly present as the proximate principles of which milk is composed. From a scientific point of view we must regard bacteria as a

[1] There is reason to believe that these bacterial counts were carried out by methods which do not allow of the enumeration of all the bacteria present. Several organisms may be represented by one colony unless the dilutions are considerably higher than was apparently the case in these examinations.

normal element of human milk and of the milk of all animals.

Bacteria in Human Milk.—In forty-three out of forty-eight specimens of human milk examined by Cohn and Neumann micro-organisms were found. These included the *Staphylococcus pyogenes albus*, the *Staphylococcus pyogenes aureus*, and the *Streptococcus pyogenes*. Honiggmann found human milk sterile in only four out of seventy-six cases. No observer has been able to report a series of cases of human milk proved to be sterile. Marfan states that we may conclude that the milk of healthy mothers obtained under aseptic precautions contains micro-organisms in nineteen cases out of twenty.[1] It is usually agreed, however, by observers, that only the earlier portions of the milk contain micro-organisms in at all large amount, and that these organisms are found in the neighbourhood of the openings of the lactiferous ducts, and not in the mammary gland itself. The organisms described are those usually found as constant inhabitants of the skin, and are necessarily unavoidable, especially in circumstances where traces of milk are always present.

The demand for a *sterile* milk is one that is, therefore, altogether superficial. In nature, under the most favourable conditions, such a milk does not exist. In the case of the cow, the possibilities of contamination are enormously increased by reason of the presence in the cow-house of excreta, and by the difficulty of keeping the cow clean.

The Effects of Contamination.—But while bacteria are present in the milk as received directly by the infant, there are two factors which are *not* present—the further external contamination of the milk after it has left the mammary gland, and the formation of toxins as a result of bacterial development in and action upon the milk.

[1] Judson and Gittings, *op. cit.*

Backhaus[1] carried out a series of investigations which demonstrate the extreme importance of attention to every detail in connection with the handling of milk. It will be seen from the figures following that apparently slight variations of method were attended with wide alterations in the bacterial content:

THE EFFECTS OF THE PRECISE METHODS OF THE COLLECTION OF MILK UPON ITS BACTERIAL CONTENT.

	Per Cubic Centimetre.
Dry milking	5,600 germs.
Wet milking	9,000 ,,
First milk	10,400 ,,
Last milk	Sterile ,,
When the cow is cleaned	20,600 ,,
When the cow is not cleaned	170,000 ,,
Udder washed	2,200 ,,
Udder not washed	3,800 ,,
If the cow is milked in the open air	7,500 ,,
If the cow is milked in a clean stall	29,250 ,,
If the cow is milked in an unclean stall	69,000 ,,
Enamelled vessels	1,105 ,,
Tin vessels	1,690 ,,
Wooden vessels	279,000 ,,
Sterilized vessels	1,300 ,,
Washed vessels	28,600 ,,
Fresh milk	6,660 ,,
Milk passed through six vessels	97,600 ,,
Turf	40,000 ,,
Good straw	150,000 ,,
Dirty straw	200,000 ,,
Fresh water	322 ,,
Trough water	228,200 ,,
Milk supplied from a good dairy farm	25,000 ,,
Milk supplied to the Königsberg market	2,000,000 ,,

Such figures as these are likely to prove more misleading than informing unless the reader bears in mind certain facts of critical importance. The 'bacterial content' of

[1] Quoted by Klimmer, 'Genügt unsere Milchkontrolle . . .' (*Jahrbuch für Kinderheilkunde*, July, 1901).

PLATE IV.

FIG. 12.—STREPTOCOCCUS LACTICUS. (× 1,000.)

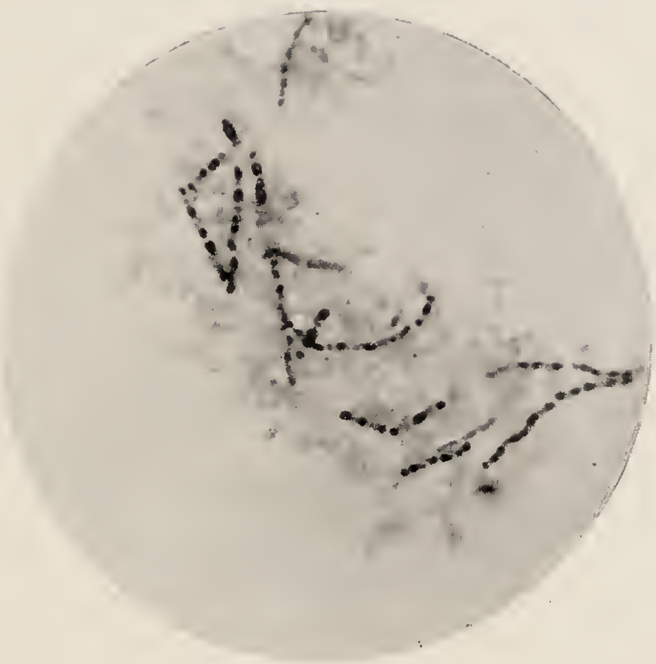

FIG. 13.—LACTO-BACILLI. (× 1,000.)

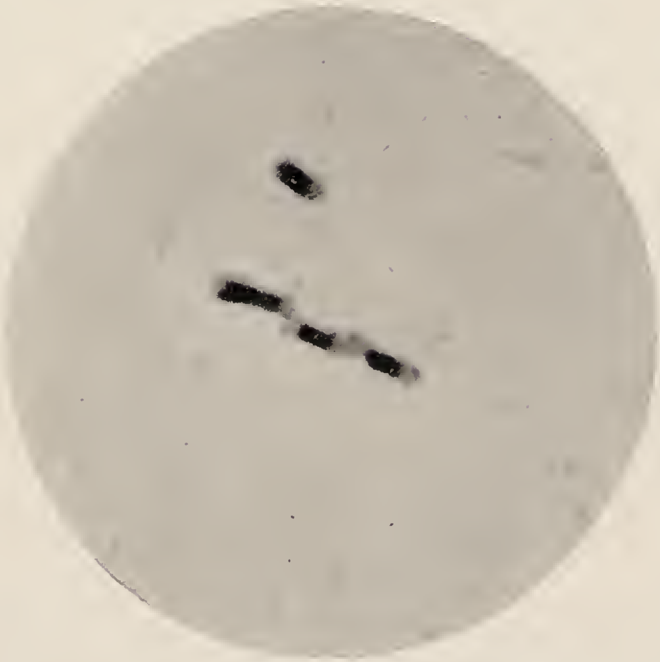

FIG. 14.—BACILLUS ACIDI LACTICI. (× 2,000.)

To face page 148.

a milk necessarily means the total number of organisms in that milk. It does not mean, as a rule, the organisms actually growing in the milk; and in order to understand the meaning of the bacterial content it is necessary to consider the method of enumeration. A sample of milk is taken, and 1 c.c. is mixed with 99 c.c. (preferably 999 c.c.) of sterilized water. One c.c. of this much-diluted milk is mixed with peptone gelatine, and, after plating out, the mixture is incubated at about 20° C. (68° F.).

When a sufficient interval has elapsed, the colonies that have developed in the medium are counted, and this number, multiplied by the factor of dilution, gives the number of bacteria present in the milk. As an indication of the number or kind of organisms capable of growing in the milk, the method is highly fallacious. The typical lactic organisms are quite incapable of growing in peptone gelatine, while the proteolytic organisms present, but not growing in milk, grow luxuriantly in gelatine.

A single observation may serve to show how misleading this method is unless the observer is conversant with the facts. On a certain Saturday a commercial milk was plated out in the manner described above, the dilution being 1 in 1,000. On the following Monday the colonies could not be counted, for the development of the proteolytic organisms had been so prolific that the gelatine was liquefied. As a representation of the bacterial development in the milk during the same period of incubation at the same temperature, this gelatine culture is wholly misleading. In order to establish a relationship between the bacterial growth in the milk and in the gelatine, it would be necessary to boil the milk; since, after milk has been boiled, the organisms growing in it are the proteolytic organisms that produce liquefaction in gelatine.

The Storing and Delivery of Milk.—The next point of importance is concerned with the procedures connected

with the storage of milk and its delivery to the consumer. In this respect, the precise temperature at which the milk is kept is of the greatest moment. Conn observed that a specimen of milk containing 153,000 bacteria per cubic centimetre contained no less than 85,000,000 twenty-four hours later.[1]

Cnopf and Escherich illustrated this rapid development by the annexed table:

RATE OF DEVELOPMENT FROM A SINGLE GERM.

	Two Hours.	Three Hours.	Four Hours.	Five Hours.	Six Hours.
44° F. - -	4	6	8	26	435
97° F. - -	23	60	215	1,830	3,800

At the time of milking, the temperature of the milk is about 100° F., and as this temperature is extremely favourable for bacterial development, and the medium is the best possible for certain organisms, the rate of development is prodigious. This fact is clearly brought out by Miquel, who observed the development in three specimens of the same milk, the only difference being the temperature.

NUMBER OF BACTERIA IN MILK EXPOSED FOR FIFTEEN HOURS.

	Per Cubic Centimetre.
At 59° F. (15° C.) - - -	100,000 bacteria.
At 77° F. (25° C.) - - -	72,000,000 „
At 95° F. (35° C.) - - -	165,000,000 „

It should, however, be pointed out that the temperature of incubation determines not only the rate of growth, but also, to a considerable extent, the kind of organisms developing in the milk. The bacteria developing in milk incubated at warm-room temperature are of a different type from the bacteria developing in milk incubated at blood temperature. This is particularly the case if the milk is one that has been obtained under conditions giving rise to contamination by colon organisms.

[1] Chapin, 'Infant Feeding,' 1903.

PLATE V.

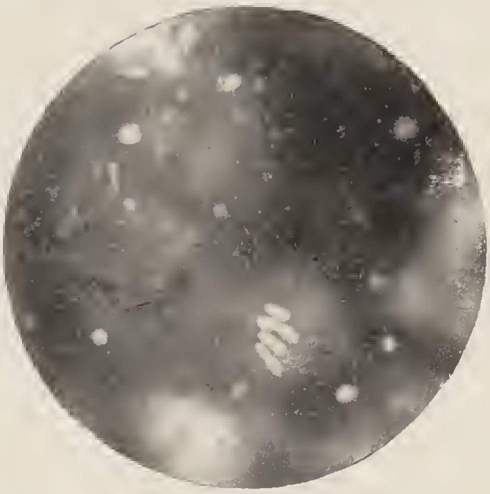

Fig. 15.—Unstained Colon Organisms growing in Raw Milk at 19° C. (× 1,000.)

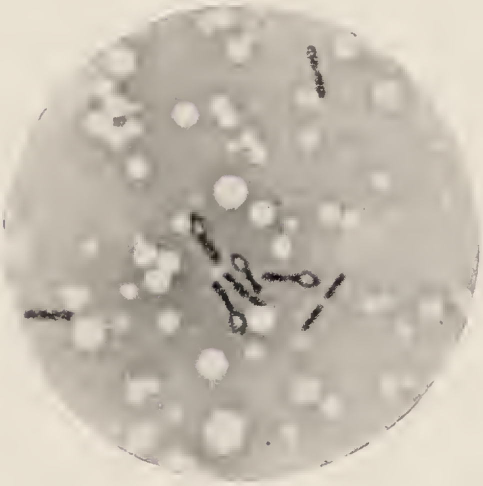

Fig. 16.—Bacillus putrificus. (× 1,000.)

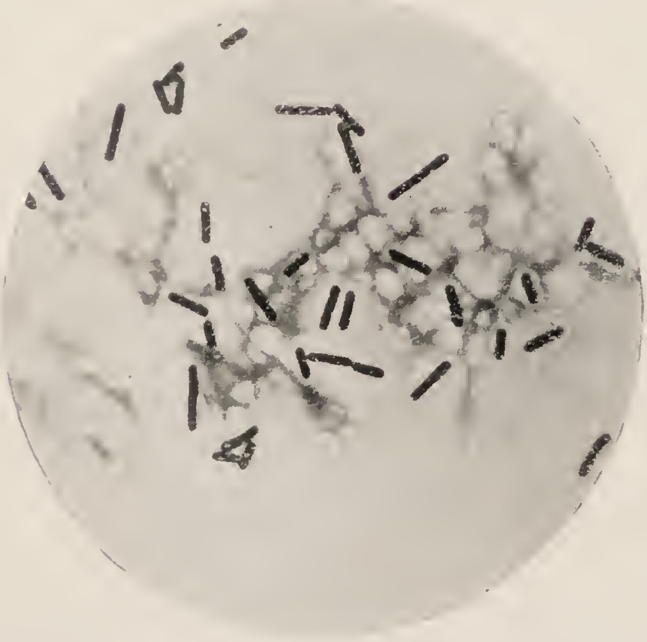

Fig. 17.—Bacillus enteritidis sporogenes. (× 1,000)

To face page 150.

Chapin quotes instances showing the importance of the bacteriological test. On a certain day in February, 1902, the count at the farm was 17,000 per cubic centimetre; at the creamery it had risen to 450,000. This was found to be due to the fact that a small quantity of water used in washing the bottles at the creamery remained in the bottles. After this, all the bottles were sterilized by steam, and the bacterial count at once became low. In March the count suddenly rose from 4,750 per cubic centimetre to 41,000. This was found to have been caused by the laying of a new floor in the creamery.

Though micro-organisms occur in milk in consequence of the presence of bacteria in the outermost portion of the lactiferous ducts, the *coutamination* of milk is most frequently due to external sources. Dust, fæces, hay, and fodder are common sources of pollution, while the milker may be the means of almost immeasurably adding to the contamination. If his hands are dirty, the contamination is great; while, if any infectious disorder be present, all the milk procured by him may be spoilt. Dirt, hair, flies, etc., swept from the body of the cow, often by her tail, also are sources of contamination.

Dairy Bacteria.—The varieties of dairy bacteria are very numerous, and the most complete description of these has been given by Conn,[1] who has succeeded in isolating over 200 species, differing more or less distinctly from one another. Many of these are, however, of theoretical rather than practical interest, and he regards the chief bacteria as belonging to three groups, all associated with lactic acid fermentation though differing in other respects.

Richmond[2] classifies the micro-organisms according to the following scheme:

[1] Twelfth Annual Report of Storr's Agricultural Experiment Station, 1899.

[2] 'Dairy Chemistry,' London, 1899.

1. Micro-organisms acting on milk-sugar causing fermentation—(*a*) with the production of lactic acid; (*b*) with the production of butyric acid; (*c*) with the production of alcohol.

2. Micro-organisms acting on proteins—(*a*) curdling milk without acidity, and not dissolving the curd; (*b*) curdling milk without acidity, and afterwards dissolving the curd; (*c*) peptonizing the proteins without curdling the milk.

3. Micro-organisms producing colouring matter.

4. Micro-organisms having no direct action on the milk.

5. Micro-organisms which are pathogenic, giving rise to specific pathological conditions.

The author's classification deals with the organisms commonly found in pure milk, and their grouping is directly related to the conditions determining their growth in and their action upon milk:

1. Micro-organisms producing lactic acid, but not producing gas. This group is represented by the *Streptococcus lacticus* and the *Lacto-bacillus of Massol* [*Bacterium caucasicum* (Kern)]. These are the typical organisms growing in pure milk at blood temperature (Figs. 12 and 13).

2. Micro-organisms producing lactic acid, carbon dioxide, and alcohol. This group embraces the whole of the colon organisms, including the *Bacillus acidi lactici* (Hueppe), *Bacterium acidi lactici* (Esten), *Bacillus lactis aërogenes* (Escherich), and the *Bacillus coli communis*. In milk incubated at blood temperature, the growth of this group is inhibited by the growth of the organisms belonging to the first group. At warm-room temperature the colon organisms group rapidly, as the growth of their antagonists is severely retarded by the low temperature (Figs. 14 and 15).

3. Micro-organisms growing in 'pasteurized' milk—*i.e.*, milk that has been subjected to a temperature between 150° F. and 212° F. (66° to 100° C.). The products of

PLATE VI.

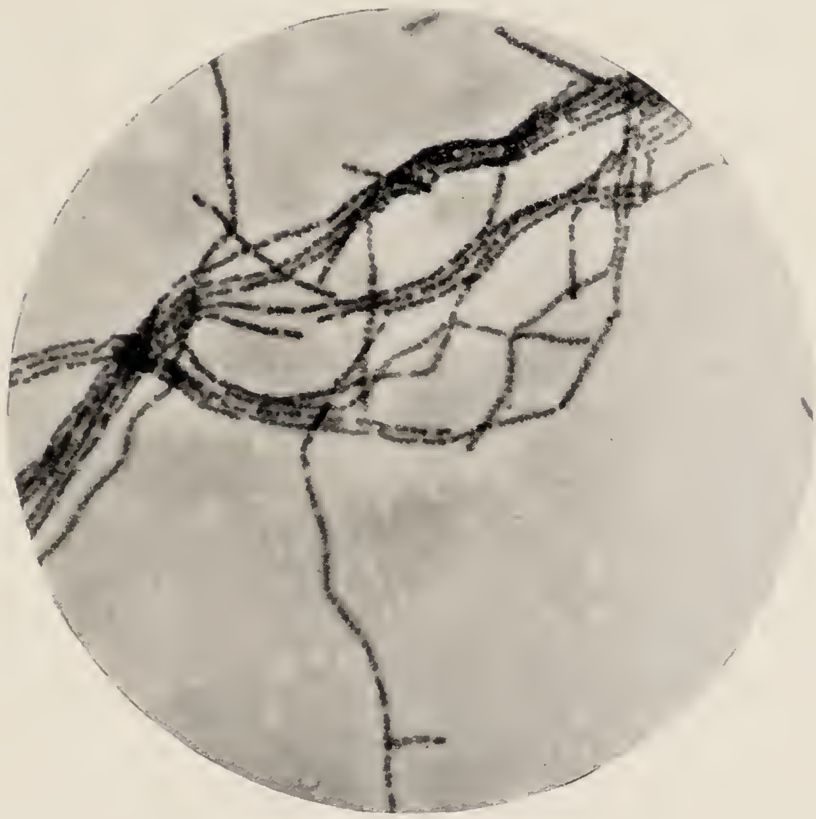

FIG. 18.—PUTREFACTIVE BACTERIA GROWING IN MILK AFTER IT HAS BEEN BOILED. (× 1,000.)

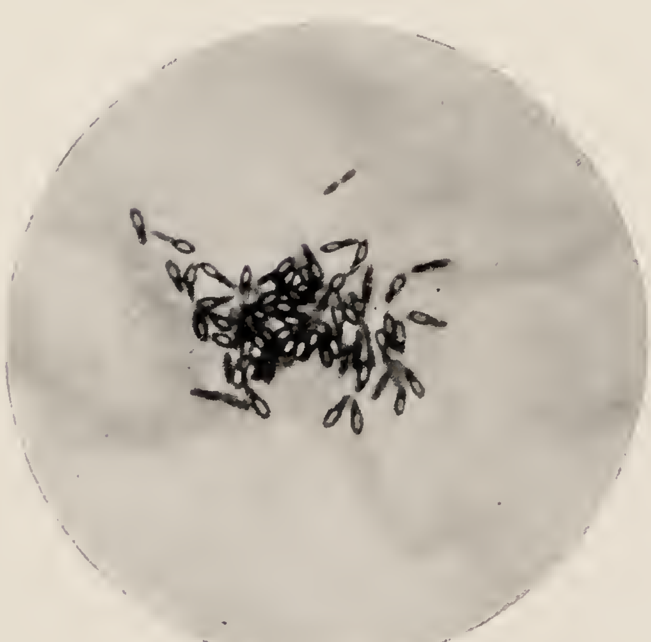

FIG. 19.—SPORES OF PUTREFACTIVE BACTERIA DEVELOPING IN MILK AFTER IT HAS BEEN BOILED. (× 1,000.)

To face page 152.

these organisms are of a highly irritant and dangerous character. The *Bacillus putrificus* (Fig. 16) and the *Bacillus enteritidis sporogenes* (Fig. 17) are examples of this group.

4. Micro-organisms growing in milk after it has been raised to 212° F. (100° C.), owing to the fact that their spores have not been destroyed. These are the organisms generally found in milk that has been boiled or 'sterilized,' and in condensed milk (Figs. 18 and 19). The group is a large one, of which the chief representatives are the *Bacillus subtilis* (Figs. 20 to 23), the *Bacillus mesentericus* (Figs. 24 and 25), and the *Bacillus mesentericus vulgatus*. These organisms growing in the intestine produce powerful alkaloidal poisons.

One highly putrefactive organism—the *Bacillus proteus vulgaris* (Figs. 26 and 27)—does not belong to this group, since it does not possess spores, and is destroyed by boiling; but it is a widely-distributed organism, and is not infrequently found growing in milk after it has been boiled, having reached the milk by means of flies, dust, etc. In common with the other putrefactive organisms, it is unable to grow in raw milk.

The Bacteriology of Pure Milk.—The *Streptococcus lacticus* is the predominant organism growing in pure milk. The purer the milk, the more free the growth of this organism. At 38° C. it grows, characteristically, in clumps and chains. The luxuriant chain formation is characteristic of pure raw milk incubated at blood heat. This organism, growing in sterilized milk in pure culture, never shows the luxuriant chain formation that is characteristic of its growth in pure raw milk. In sterilized milk and in raw milk incubated at warm-room temperature the organism grows in short chains of from 2 to 6 units or as isolated diplococci (Figs. 28 to 30).

The *Streptococcus lacticus* produces a moderate amount of lactic acid, so that pure raw milk incubated at 38° C. curdles in rather less than twenty-four hours;

incubated at 19° C., the milk should not curdle under about seventy-two hours. If the milk is contaminated, the growth of the streptococcus is interfered with, and colon organisms develop. These organisms produce gas, with the result that the curd is pitted, and if the gas production is excessive the curd can be brought to the surface of the milk. Thus, one of the important tests of pure milk is the time of curdling at a given temperature and the character of the curd formation. A dirty milk will curdle in thirty hours or less at 19° C., the curd being gas-blown. A clean milk will not curdle under forty-eight hours; a really pure sample should not curdle under seventy-two hours, the curd being smooth and homogeneous. (In the author's laboratory the two kinds are generally referred to as 'honeycombed' and 'blancmange' curds.) After about seventy-two hours' incubation at 19° C., various forms of the fungi known as 'moulds' begin to appear. The photo-micrographs show the common appearance of the organisms (Figs. 31 and 32). At 38° C. these fungi seldom develop, as the temperature is too high. The organisms growing in pure milk incubated at 38° C. are confined, as a rule, to three groups. The *Streptococcus lacticus* grows rapidly for about twenty-four hours; at the end of this period the growth of the organism ceases owing to the development of acidity. For about forty-eight hours no further development is seen; then two other organisms make their appearance—yeasts and lacto-bacilli (Figs. 33 and 34).

The lacto-bacilli predominate in cultures incubated for long periods at blood temperature. Some varieties are extremely aciduric, and exhibit remarkable morphological changes at various stages of their growth. The two photo-micrographs of the lacto-bacillus, 'No. 41' (Infants Hospital), show the striking differentiation of structure and great morphological variation characteristic of these organisms (Figs. 35 and 36).

PLATE VII.

Fig. 20.—Bacillus subtilis (Indian Ink Method). (× 2,000.)

Fig. 21.—Bacillus subtilis in Peptone Broth (taken during Life). (× 1,000.)

To face page 154.

The purest milk contains a great variety of organisms; but the selective power of milk is such that the vast majority of organisms are quite unable to grow in it when the milk is in its natural condition and at its natural temperature.

These facts are of paramount importance in regard to the biochemical processes taking place in the alimentary canal of the infant.

The Development of Acidity in Milk.—The *initial acidity* is not due to the action of micro-organisms, but to the chemical composition of the fluid. This acidity varies, as a rule, between 15 and 18 degrees. A comparatively high initial acidity does not afford evidence of imperfect methods of milking, for a milk with 18 degrees may be quite as fresh and as pure as a milk with 15 degrees. A milk with a high protein content is generally found to give a high reading, for caseinogen invariably behaves as an acid.

The *development* of acidity in milk is due entirely to the action of micro-organisms, and, consequently, the temperature at which the milk is kept and the time during which it is exposed to this temperature are the chief factors determining the rate of acid production.

The method of determining the acidity employed in the laboratory is as follows:

To 100 c.c. of milk are added 5 c.c. of a 0·5 per cent. solution of phenolphthalein in 50 per cent. alcohol. The milk is then triturated with $\frac{N}{10}$ NaOH till the milk shows a faint pink tinge, which does not disappear on stirring. Each cubic centimetre of $\frac{N}{10}$ NaOH neutralizes 1 degree of acidity, so that the number of cubic centimetres employed in order to destroy the acidity of the specimen gives the number of degrees of acidity present in the milk.

Immediately the milk is received in the laboratory its acidity is determined; the milk is then placed in a sterilized covered vessel, and incubated at the specified tem-

perature. At the specified intervals a sample of the milk is taken, and its acidity is duly determined and recorded.[1]

The first observation demonstrates the typical features of the development of acidity in a really clean, fresh milk incubated at a constant temperature of 19° C. (67° F.)—

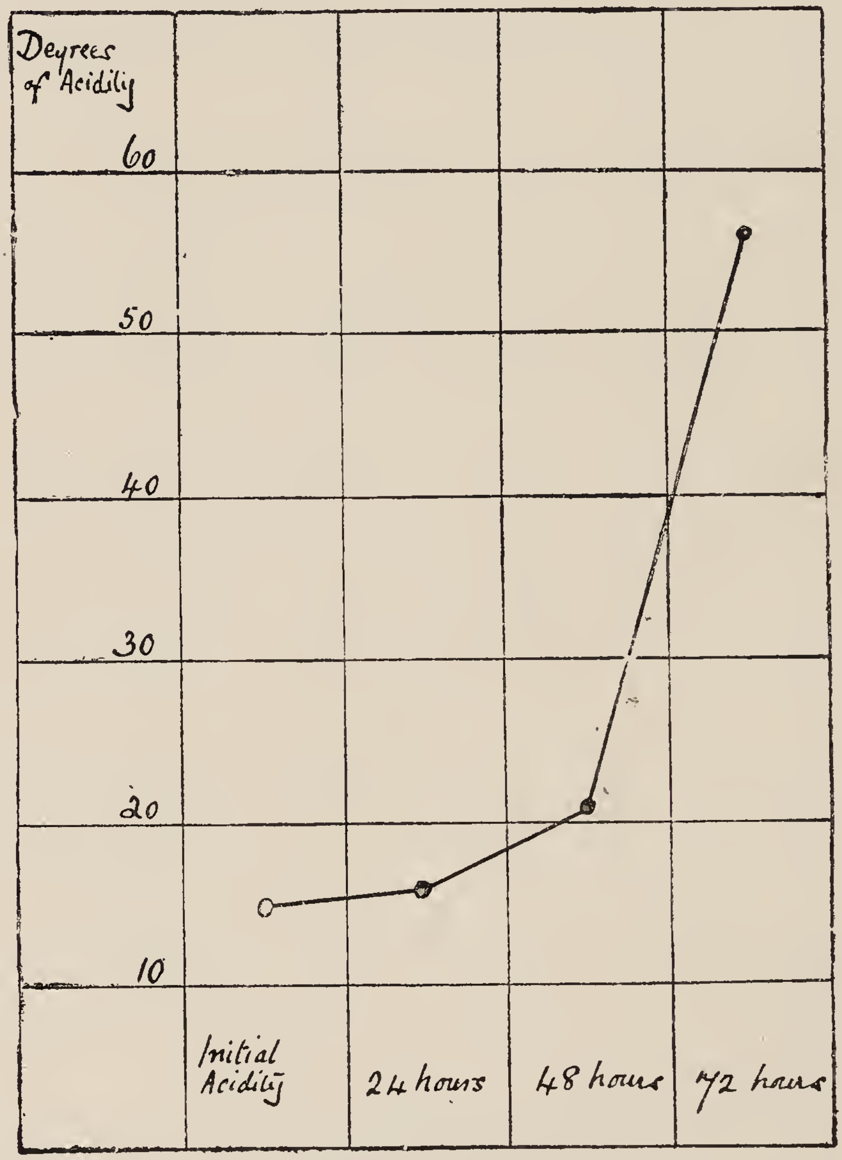

FIG. 38.—CURVE SHOWING THE DEVELOPMENT OF ACIDITY IN A PURE MILK INCUBATED AT 19° C. (67° F.) FOR SEVENTY-TWO HOURS.

i.e., at a temperature rather higher than that of the ordinary living-room.

The initial acidity was 15·5 degrees; at the end of the

[1] This account is taken from a paper by the author on 'The Development of Acidity in Cow's Milk, and its Relation to Time and Temperature,' read before the Glasgow Obstetrical and Gynæcological Society, and published in the *Glasgow Medical Journal*, December, 1911.

PLATE VIII.

FIG. 22.—BACILLUS SUBTILIS, SHOWING SPORES. (× 2,000.)

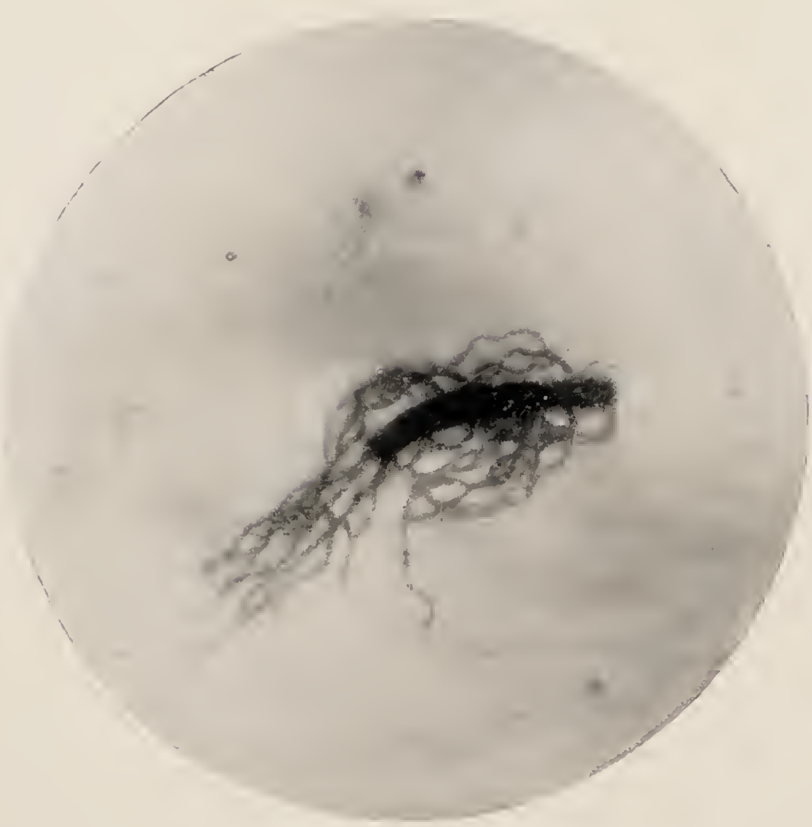

FIG. 23.—BACILLUS SUBTILIS, SHOWING FLAGELLA. (× 2,000)

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first twenty-four hours the acidity was 16·3 degrees; at the end of the second twenty-four hours it was 21 degrees; at the end of the third twenty-four hours it was 57 degrees.

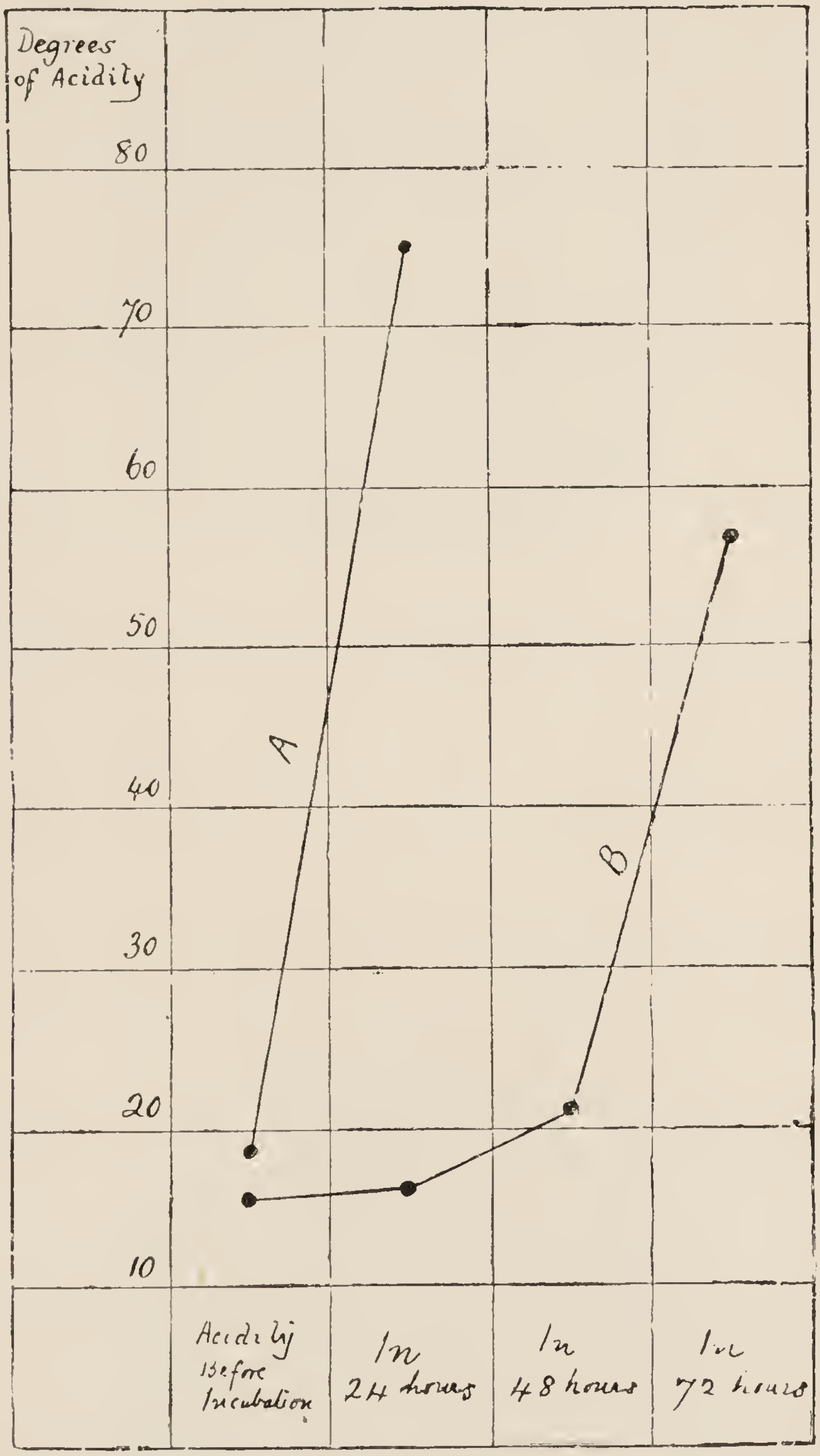

FIG. 39.—CURVES SHOWING THE DEVELOPMENT OF ACIDITY AT 19° C. (67° F.) IN—(*A*) COMMERCIAL MILK; (*B*) THE HOSPITAL MILK. (SUMMER SEASON.)

(One degree of acidity = 0·009 per cent. lactic acid.) The diagram (Fig. 38) shows graphically the almost inappreciable rise in acidity during the first twenty-four hours, the definite rise in the next twenty-four hours, and the

marked production of acid between forty-eight and seventy-two hours.

The milk used in this experiment was a sample taken from the milk laboratory of The Infants Hospital.

The contrast between the behaviour of the hospital milk and of commercial milk is shown in the next experiment. The commercial milk was incubated at the same

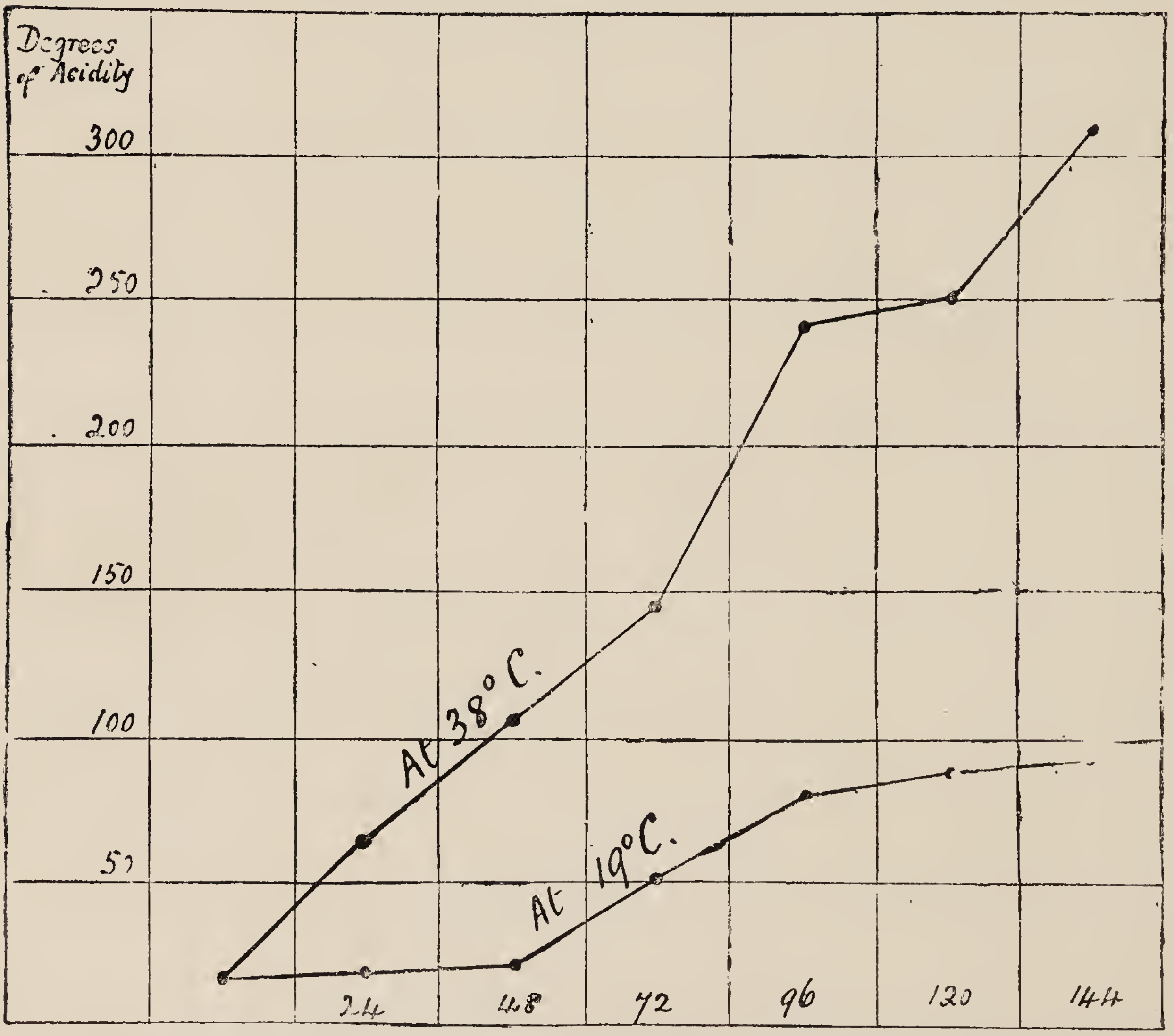

FIG. 40.—CURVES SHOWING THE DEVELOPMENT OF ACIDITY IN PURE MILK INCUBATED AT 38° C. AND AT 19° C. OVER A PERIOD OF SIX DAYS.

time in the same incubator. The production of acid in the commercial milk was so rapid that in twenty-four hours it exceeded the production of acid in the hospital milk in seventy-two hours. This contrast is graphically shown in the curves (Fig. 39). Both of these determinations were made in August, 1911.

At 38° C. (blood temperature) the production of acid

PLATE IX.

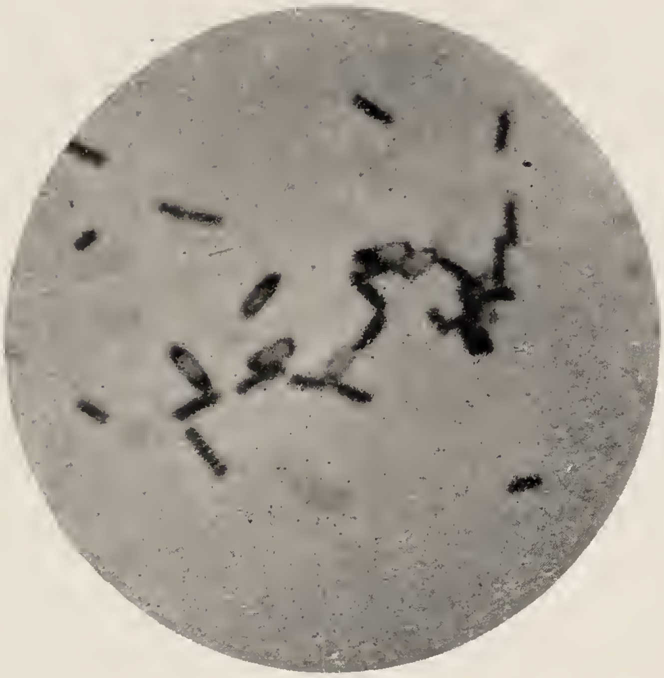

Fig. 24.—Bacillus mesentericus and Spores.
(× 2,000.)

Fig. 25.—Bacillus mesentericus (Indian Ink Method).
(× 2,000.)

To face page 158.

proceeds much more rapidly. The relative rate of acid production is shown in Fig. 40. At 19° C. the develpment of acidity practically ceases after the first three or four days. At 38° C. this is not the case, for the amount of acid steadily increases till it reaches about 3 per cent. Such high amounts of acid are, however, never reached

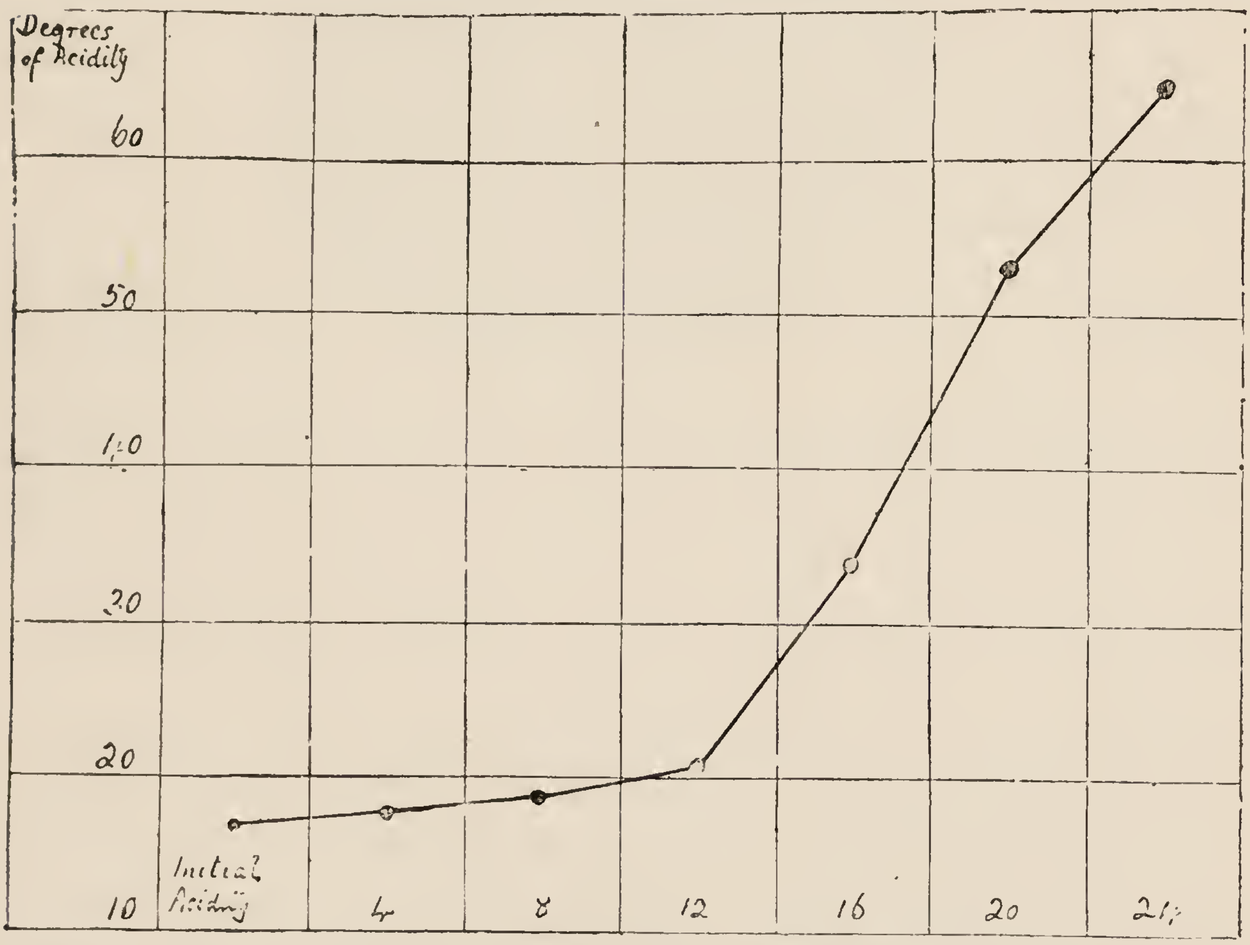

Fig. 41.—Curve showing the Development of Acidity in Pure Milk incubated at 38° C. for Twenty-Four Hours, the Determinations of Acidity being made at Intervals of Four Hours.

in the alimentary canal, as this acid development only occurs when the same sample of milk is subjected to prolonged incubation. The rapid rise occurring at 38° C. at the end of seventy-two hours was due to the active growth of yeasts in the milk. At 38° C. the rapid production of acid always produces curdling within twenty-four hours, but it should be noted that the production of acid in pure milk at this temperature is extremely gradual in the first twelve hours. The rate of acid development is shown by the following figures:

DEGREES OF ACIDITY ABOVE THE INITIAL ACIDITY.

1st four hours - - - -	1 degree.
2nd ,, - - - -	2 degrees.
3rd ,, - - - -	4 ,,
4th ,, - - - -	17 ,,
5th ,, - - -	36 ,,
6th ,, - - - -	48 ,,

Fig. 41 shows graphically the extremely slow development of acid in the earlier stages of incubation, and its rapid rise in the later stages.

Pathogenic Bacteria.—The part played by bacteria present in milk in the dissemination of specific infective diseases, such as scarlatina, diphtheria, etc., has already been referred to. In general it may be said that these infections arise from—(1) disease in the milkers or those concerned with the handling of the milk, or their families; (2) the infected water used with the object of cleansing the various utensils or for adulteration. In regard particularly to scarlatina, the source of infection has frequently been traced in the most complete manner to the milk-supply. It is necessary to point out, however, that in all such cases the cause of the infection has not been some departure from a high standard of sanitary excellence. It has arisen from gross neglect of the most elementary precautions. The cases recorded in Chapter VI. afford clear evidence of this.

In reference to the tubercle bacillus, it must be admitted that the evidence of direct infection from bovine tuberculosis is almost entirely lacking so far as the incidence of disease in infancy and early childhood is concerned. For tuberculosis is a rare disease in infancy. This, however, is of small moment in reference to practical dairy management. The milch cow should be demonstrably healthy, and in no properly managed dairy should milk be taken from a cow suffering from tuberculosis, either general or localized. The systematic testing by *tuberculin*,

PLATE X.

FIG. 26.—BACILLUS PROTEUS VULGARIS (INDIAN INK METHOD). ($\times$ 2,000.)

FIG. 27.—BACILLUS PROTEUS VULGARIS WITH FLAGELLA (INVOLUTION FORM). ($\times$ 2,000.)

To face page 160.

and the immediate exclusion of diseased cows giving the reaction, should be carried out by the intelligent farmer in his own interests.

A large group of bacteria, not directly pathogenic, are associated with alterations in milk resulting in the production of pigment. *Blue milk* is caused by the *Bacillus cyanogenus* (which is only active in the presence of acid), the *Bacillus cyaneo-fluorescens*, and the *Bacillus janthinus*. *Red milk* is due to the *Bacillus prodigiosus*, *Bacillus lactis erythrogenes*, *Spirillum rubrum*, *Micrococcus cinnabareus*, and the *Sarcina rosea*.

Various other changes in the physical characters of milk are caused by other organisms. Viscous milk is due to the action of the *Bacillus lactis viscosus*, the *Bacillus lactis pituitosi*, and several other varieties.

In this summary the author has endeavoured to point out the essential features of the bacteriological contamination of milk. Exaggeration in these matters is much to be deplored, and that there has been an exaggeration of some aspects of the question can scarcely be doubted. While certain bacteria are the source of the most virulent diseases, other bacteria play a part as powerful in the prevention of disease. The facts demonstrated by independent and authoritative observers in regard to the antagonism between the lactic acid and the putrefactive bacteria afford a striking instance of this aspect of the subject. The relationship between the hygienic bacteria and the digestion of the infant again illustrates the value of certain forms of micro-organisms.

The bacteriological analyses of human milk which have been quoted show how exceptional it must be for the human infant fed by its mother to receive a sterile milk. In reference to substitute feeding, we have to secure that the milk used shall be pure, and, as regards bacteria, as closely as possible approximating to its condition when received by the calf direct from the cow.

Given a healthy cow, the deleterious bacteria arise entirely from growth and development of the bacteria occurring during the storage of the milk at a temperature favouring this, and from contamination arising during the milking or at some later stage in the handling of the milk. All our endeavours should be exerted to preserve its pristine purity, and the technique here required is one demanding persistent vigilance.

PLATE XI.

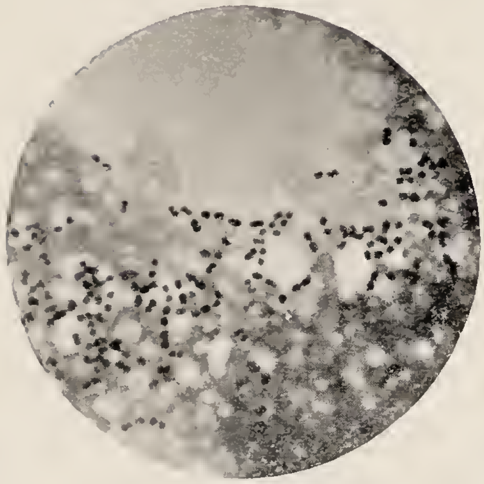

Fig. 28.—Streptococcus lacticus. Growth (20 Hours) in Sterilized Milk at 38° C. (× 1,000.)

The indistinct appearance of the organisms is a characteristic feature of the growth under these conditions.

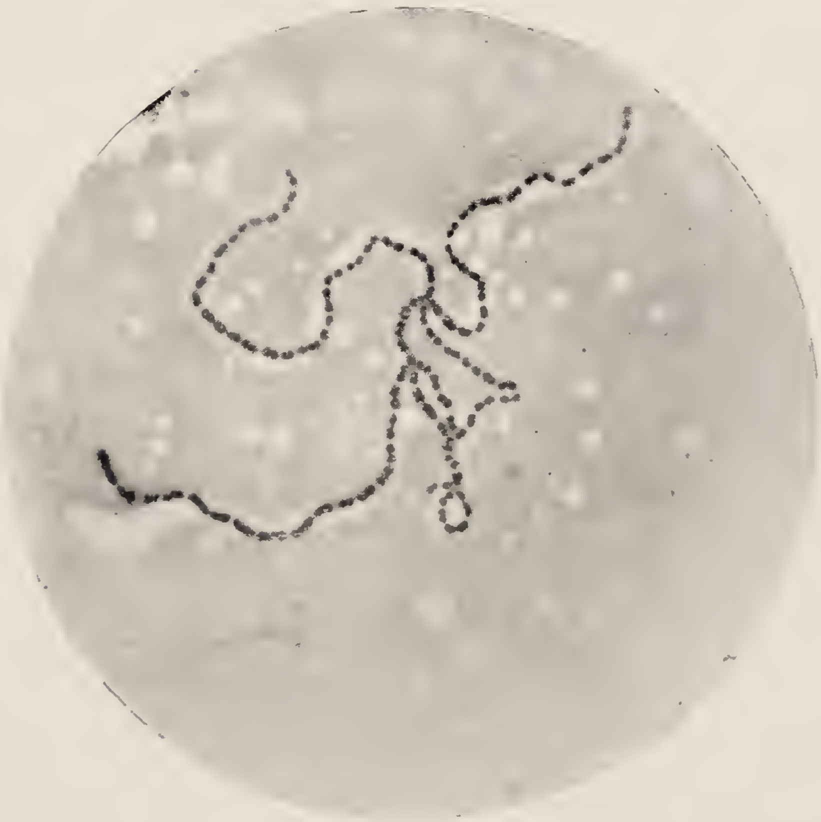

Fig. 29.—Streptococcus lacticus. As found in Raw Milk incubated for Eight Hours at 38° C. (× 1,000.)

To face page 162.

CHAPTER IX

THE FUNCTIONS OF BACTERIA IN RELATION TO DIGESTION

Bacteria present in the Stomach.—At birth the contents of the stomach and intestine are sterile; within a few hours numerous forms of bacteria are found, and in a few days the whole alimentary tract contains myriads of organisms. Van Puteren[1] examined the stomach contents of forty healthy infants from four to seven days old, some being breast-fed and others fed on cow's milk. The stomach contained about twenty times as many organisms in the case of those infants fed on cow's milk as those that were breast-fed. This variation is undoubtedly due to the contamination of cow's milk. In Van Puteren's figures the evidence of contamination in the case of the hand-fed is very distinct—the presence of the *Bacillus subtilis* and of the *Bacillus butyricus* almost certainly owing their origin to this source.

He found the *Bacillus lactis aërogenes* present in 37·6 per cent. of the breast-fed and in 45 per cent. of those bottle-fed; the *Bacillus subtilis* was present in 11·7 per cent. of the breast-fed and in 36·8 per cent. of the bottle-fed. In the breast-fed the *Oidium lactis* was found in 12·9 per cent., and in the others in 27·3 per cent. The *Staphylococcus pyogenes aureus* was present in 16·4 per cent. of the breast-

[1] 'Micro-Organisms in the Stomach and Intestine of the Infant.' *Vrach* (St. Petersburg), vol. ix.

fed and in 27·2 per cent. of the bottle-fed. The *Bacillus fluorescens liquefaciens* and the *Bacillus butyricus* were not found at all among the breast-fed, but the former bacillus was found in 24·3 per cent. of the bottle-fed, while in every case where the infant was fed upon cow's milk the *Bacillus butyricus* was present. The presence of this bacillus was undoubtedly due to the fact that the milk was boiled or sterilized prior to administration. In raw cow's milk the development of this bacillus is excessively rare.

While many forms of bacteria present are the result of the external contamination of cow's milk, others are present in the stomach, whether the method of feeding is natural or otherwise. Of these latter the lactic acid bacilli are the most important, since their functions are of great value to the infant, and it is noteworthy that the difference in regard to the *Bacillus lactis aërogenes* between the breast- and bottle-fed infants is less than 10 per cent.

In reference to the number of bacteria present, Langermann[1] found that the stomach of the infant normally contained from 3,700 to 240,000 bacteria per cubic centimetre; that, even in the presence of free hydrochloric acid, they existed in numbers between 3,200 and 6,400 per cubic centimetre, while in cases of digestive derangement the number of bacteria may be enormous.

Jeannin[2] published the results of some valuable investigations on the bacteriology of the mouth of the suckling:

1. At birth the infant's mouth is as a rule aseptic. 2. Bacteria invade the mouth within the first hours of life and before the child has been put to the breast. These organisms, always in small numbers, are *Streptococcus salivæ*, *S. aërobius micros*, and *Staphylococcus parvulus*. 3. The beginning of suckling causes free bacterial development. Within a few hours, from three to six species, aërobian

[1] *Jahrbuch für Kinderheilkunde*, Bd. xxxv., 1893.

[2] *L'Obstétrique*, July, 1904.

PLATE XII.

FIG. 30.—STREPTOCOCCUS LACTICUS. GROWTH IN STERILIZED MILK (EIGHT DAYS AT 19° C.). (× 1,000.)

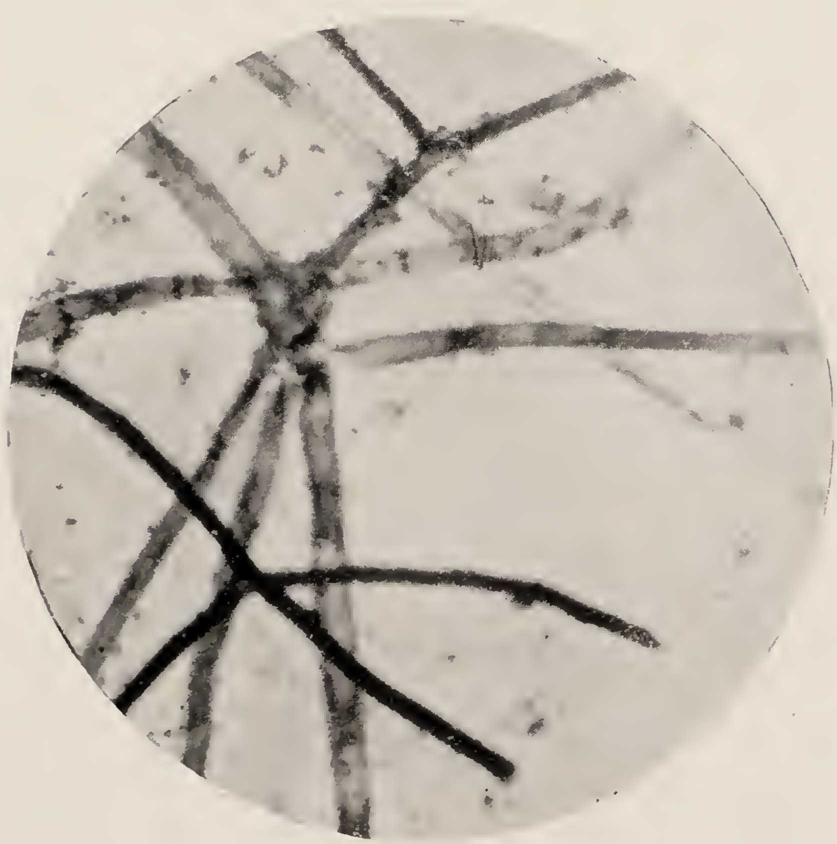

FIG. 31.—MOULDS GROWING IN MILK. (× 500.)

To face page 164.

and anaërobian, make their appearance. 4. There is an almost fixed formula for the bacteriology of the healthy suckling's mouth. There are some four to six species, mostly aërobian (pneumococci, streptococci, staphylococci, and *Bacillus coli*). The anaërobians, always in a majority, are relatively inactive, and do not develop gas. 5. There is also a pathological formula for infants which are sickly, independent of diseases where specific germs are to be found. The microbes are very abundant and multiply actively, and the anaërobians increase still more in proportion to the other kinds, and develop gas when cultured. 6. Extreme development of the microbes of the infant's mouth is invariable amongst infants placed in the incubator.

Bacteria present in the Intestine.—Escherich was the first to thoroughly investigate the part played by bacteria, and his conclusions are here summarized. At birth the meconium is sterile, but infection by the mouth and rectum quickly occurs, and in a short time almost any form may be found, but chiefly such putrefying forms as the *Proteus vulgaris*.

When the infant is fed, and the refuse of milk together with the intestinal secretion replaces the meconium, a marked change is seen, and only two forms are commonly found—the *Bacillus lactis aërogenes* and Brieger's bacillus, the first in the upper, the second in the lower, parts of the intestine. When the infant comes to a mixed diet, numerous other forms appear. Escherich attributes the absence of the other forms during the milk diet to the association of this diet with the presence of the *Bacillus lactis aërogenes*. This bacillus is found in great numbers in the upper part of the intestine in milk-fed infants, and it converts a great part of the lactose into lactic acid, and thus prevents the development of other micro-organisms.

Biedert's observations[1] confirm these. The *Bacillus*

[1] *Kinderernährung im Säuglingsalter*, 1900.

lactis aërogenes splits up lactose into lactic acid, carbon dioxide and water, and thus fermentation of the chyme occurs. This organism is chiefly present in the upper part of the small intestine. It is responsible for the production of the acid reaction.

The *Bacillus coli communis* is the chief organism present in the lower intestine. It grows in the presence of alkaline reactions, and is capable of fermenting lactose, with the production of lactic acid. It is also characterized by its function of splitting the neutral fats into fatty acids. Normal lactic fermentation is accomplished by means of the *Bacillus acidi lactici.* Until the supply of lactose is practically exhausted, and the activity of this bacillus is consequently inhibited, the *Bacillus coli communis* does not come into action. As soon, however, as this is accomplished, the latter acts on remnants of lactose and albumin and breaks up the fats.

In correspondence with the cessation of activity of the lactic acid bacilli and the development of activity by the colon bacillus towards the lower part of the intestine, the strong acid reaction declines, until, at the beginning of the colon, the reaction is alkaline or only slightly acid. As long as the intestinal reaction is acid, the fermentative changes above described take place, but *putrefaction* does not usually occur till the acid reaction is either very weak or has been replaced by an alkaline reaction.

These facts demonstrate at once how complex and how mutually interdependent are the processes of digestion and absorption, especially in the young infant living exclusively on a milk diet. In the management of infant feeding and in the treatment of disorder, these factors have received but scant recognition.

Many methods practised in infant feeding and in infantile disorders must be regarded, in the light of these facts, as altogether arbitrary and harmful. Such complex processes as these can only be regulated when the essential

PLATE XIII.

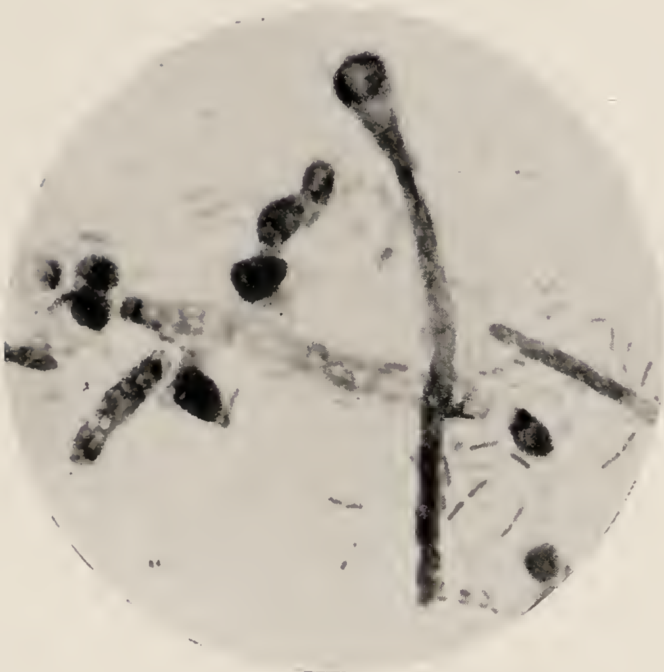

FIG. 32.—MOULDS GROWING IN MILK. (× 1,000.)

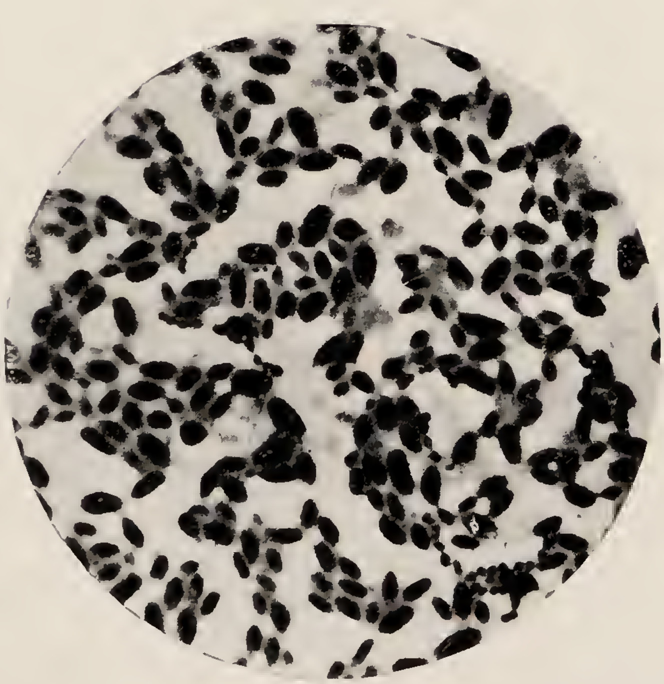

FIG. 33.—YEASTS GROWING IN MILK AT 38° C. (× 1,000.)

To face page 166.

factors receive due recognition. They illustrate, for instance, the complete futility of the systematic use of intestinal antiseptics.

The use of preservatives is to be strictly condemned for the same reasons as the boiling of milk. These preservatives inhibit the action of the delicate lactic organisms, and thus encourage the growth of the putrefactive bacteria. Milk treated with preservatives putrefies, as does boiled milk. It does not undergo the decomposition characteristic of raw milk. It need hardly be said that the administration of drugs, such as boric acid, to young infants is altogether indefensible.

According to the author's observations, the distinction between the *Bacillus lactis aërogenes*, the *Bacillus acidi lactici*, and the *Bacillus coli communis*, cannot be maintained. All these organisms belong to one group—the colon group—and whilst they ferment lactose under conditions of health, they are all potentially proteolytic organisms. The organisms active in the small intestine of the infant are the lactose-fermenting, non-gas-producing, and non-proteolytic organisms. Most of these organisms were not recognized by the earlier observers, for the reasons that the culture media employed for isolation did not permit of their growth. None of them are capable of growing in peptone broth or in gelatine. The failure to realize this important fact is a frequent source of error at the present time.

Another consideration which must always be borne in mind in regard to the bacteriology of digestion is the important part played by symbiosis. The growth of an organism in pure culture is different from its growth when in company with other organisms. This may readily be recognized by comparing the growth of lacto-bacilli in pure culture with that of a mixed culture of lacto-bacilli and the *Streptococcus lacticus*. The latter organism exercises such a marked control

that the morphology of the lacto-bacilli is entirely altered.

The bacteria typically growing in the intestine of the healthy infant are Gram-positive, and are chiefly represented by the *Streptococcus lacticus*, the *Bacillus bifidus*, the bacillus of Massol, and the *Bacillus acidophilus*, this last organism being a type of the lacto-bacilli described by Kendall[1] as aciduric organisms. The presence of the *Streptococcus lacticus* is extremely important in regard to its influence in controlling the growth of the other organisms. It has been little referred to, partly on account of its failure to grow on ordinary culture media, and, secondly, because it is rarely to be found when a direct microscopic examination of the intestinal dejection is made. It is, as a rule, strictly confined to the small intestine, and flourishes more in the jejunum than in the ileum.

The strict confinement of the streptococcus to the small intestine has been strikingly illustrated in numerous cases under the author's observation, where large doses of the streptococcus have been administered several times a day for some weeks without the organism being found on direct microscopical examination of the dejections. On the other hand, when sterilized milk is inoculated from the dejection, the streptococcus rapidly becomes the dominant organism. The influence of this organism may readily be demonstrated in such cases by suspending the administration of the cultures; constipation and putrefactive changes in the dejections soon become evident, and only yield when the administration of the cultures is renewed. It would appear to be established that a fresh supply of the *Streptococcus lacticus*, in a *faintly* acid medium, such as milk, is an essential requirement of the infant; for this organism rapidly degenerates when kept in its own culture medium.

[1] 'Observations on Aciduric (Acidophilic) Bacteria,' *Journal of Medical Research*, February, 1910.

PLATE XIV.

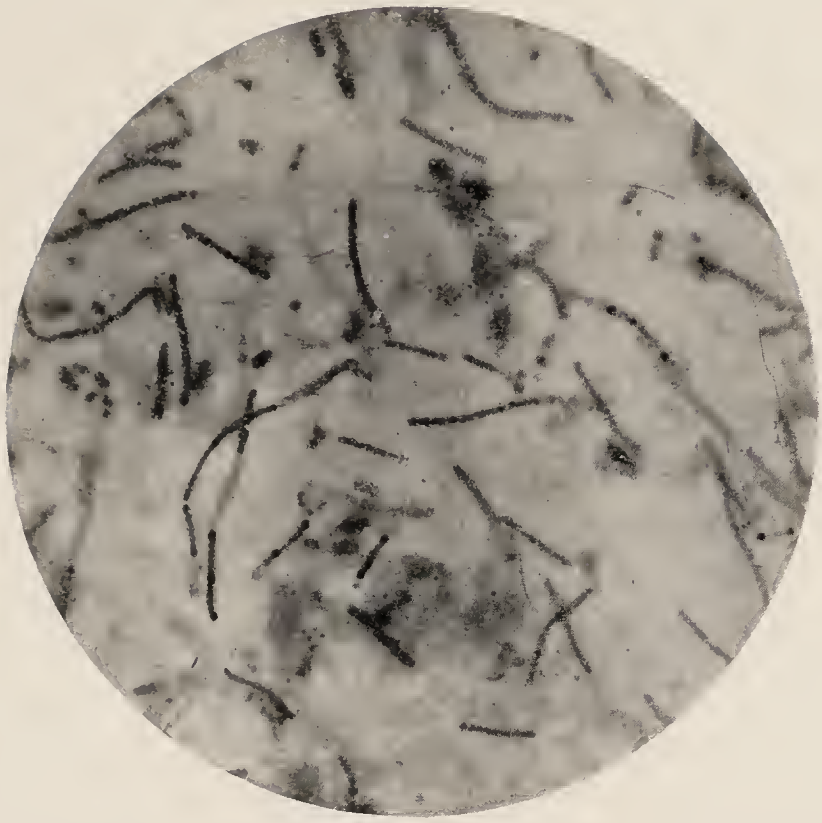

FIG. 34.—LACTO-BACILLI GROWING IN MILK INCUBATED FOR SOME DAYS AT 38° C. (× 1,000.)

FIG. 35.—LACTO-BACILLUS: 'NO. 41,' INFANTS HOSPITAL. (× 1,000.)

To face page 168

In the author's laboratory great pains are taken to keep the non-proteolytic organisms in a vigorous condition by replanting them every day in a fresh medium. All these organisms are delicate, and are extremely susceptible to the effects of their own products. The *Streptococcus lacticus* in pure culture, in its most favourable medium, will die out in the course of a fortnight, and long before death occurs the morphological changes undergone by the organism indicate its rapid degeneration.

There are, however, certain conditions in which organisms such as the streptococcus and the lacto-bacilli apparently become pathogenic, or, at any rate, associated with pathogenic conditions. These are very striking cases, and are very different in all their features from the toxæmic group of intestinal affections. There is a marked acid production, the dejections are frequent and watery, the buttocks are excoriated, and microscopical examination shows a typical picture. In some cases masses of streptococci are seen, in others lacto-bacilli. A characteristic feature referred to by Kendall and by Finkelstein[1] is the tendency of these organisms in such cases to be found 'almost in pure culture.' This is so much the case that in several of the author's bacteriological reports he has specifically drawn attention to this fact. It is difficult to account for these cases bacteriologically. The organisms do not appear to be in any way different from those found in large numbers in healthy infants. The clinical evidence is here not without its importance.

The type of infant in which this condition is seen is very different from the normal. When this condition occurs spontaneously, it is generally found in an infant a few weeks of age ; the infant is very delicate, and generally immature. It would appear that the natural

1 *Deut. Med. Woch.*, 1900, xxii. 263, quoted by Kendall in his paper previously cited.

organisms are too powerful for the infant, and this overpowering of the infant is not confined to the organisms, for the natural food of the infant—breast-milk—is generally found to greatly upset the immature infant. In these cases a cooked milk with a minimum amount of carbohydrates gives rise to a gradual change in the flora, and the dominance of the lactic organisms ceases. Similar conditions may be seen in infants treated with massive doses of the lactic organisms to contract proteolytic changes. In such cases there may be a rapid revolution, the lactic organisms becoming so dominant as to produce much irritation and diarrhœa.

These cases serve to show the essential nature of the condition in which acid production becomes extreme. It should, however, be said that, with proper technical management, such overdosing should never occur. The proper treatment by lactic cultures is by small doses at frequent intervals—for example, a few cubic centimetres given with each feed. Provided that the administration is controlled by microscopic examination of the dejections, and by attention to the clinical facts, the possibility of overdosage to any serious extent is entirely prevented.

These considerations enable us to appreciate the fact that the bacteriology of digestion is a complicated process, governed by the constitution of the infant, the amount of acid necessary to moderate peristalsis, the diet of the infant, and the effects of symbiotic growth of the bacteria. Kendall carefully observed the effects of diet on dogs in regard to the intestinal flora, and reported as follows:[1]

A diet rich in protein, particularly meat, and relatively poor in easily fermentable carbohydrates, is attended by an extension of the habitat of the liquefying bacteria, and usually by an increase of the aërogenic bacilli (*B. coli*), while the growth of the acidophilic (aciduric) bacteria is restricted. In such instances there

[1] *Journ. Biol. Chem.*, 1909, vi. 268.

PLATE XV.

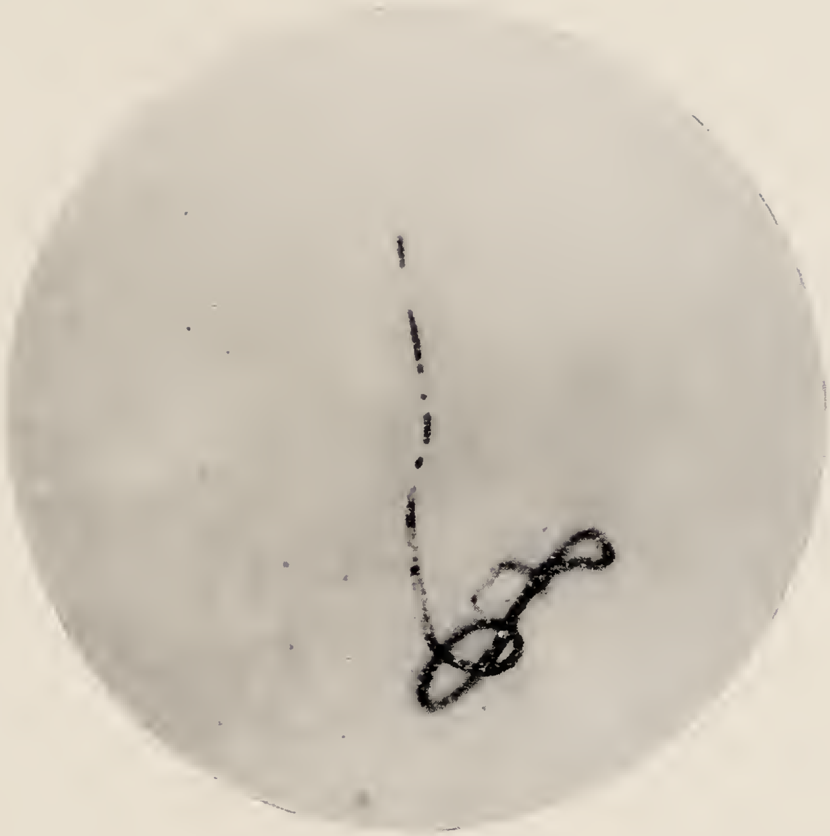

FIG. 36.—LACTO-BACILLUS: 'NO. 41,' INFANTS HOSPITAL.
(× 1,000.)

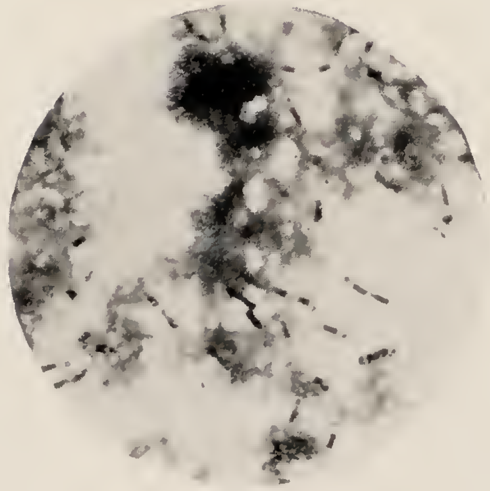

FIG. 37.—COLON ORGANISMS FROM A CASE OF COLON TOXÆMIA.
(× 1,000.)

To face page 170

is usually a decided augmentation of the gas volume above that characteristic of a mixed diet, the sediments show increased numbers of subtiloid bacilli and aërogenic organisms, while the acidophils are relatively poorly represented. A rich carbohydrate diet, on the other hand, particularly if the carbohydrates are easily fermentable sugars rather than starches, results in a limitation of the liquefying bacteria, and a more or less marked restriction of the development of the aërogenic forms, accompanied by a decided increase in the acidophils. The gas volume is decreased, and in the sediments are seen the acidophilic bacteria prominently represented, while the other types are suppressed to a considerable or lesser extent.

The experimental study of the organisms commonly found in the intestinal tract throws much light on the essential features governing the growth and action of the bacteria in the intestine. Sterilized milk, planted with both the *Streptococcus lacticus* and the *Bacillus subtilis*, and incubated at blood-heat, yields a practically pure culture of the *Streptococcus lacticus*.

The *Bacillus subtilis* and the *Bacillus coli communis* are remarkable for their symbiotic growth in various media, including sterilized milk. This symbiosis is an extremely dangerous one to the infant, and is of importance, since the dominance of colon organisms may lead to the highly dangerous development of the putrefactive organisms, of which the *Bacillus subtilis* is one of the chief representatives.

In the normal infant the factor determining the character of the intestinal flora is the diet. The natural diet not only contains fat, lactose, and proteins, but also the purely fermenting organisms which, by their growth and products, inhibit proteolysis, and thus protect the infant from the putrefactive changes which would otherwise occur. In order that the infant may obtain naturally a continuous supply of these organisms, it is essential

that the milk shall be in its natural condition. The bacteriological abnormalities found in the intestine of the infant have their essential origin in improper feeding. The selective influence of the improper diet soon comes into action, and gradually the quality of the bio-chemical processes occurring in the intestine is changed till, finally, there is a complete reversal of the natural conditions.

CHAPTER X

THE CHEMISTRY OF INFANTILE DIGESTION

THE processes of digestion and absorption in the infant present many important differences from those observed in the adult, and, as would naturally be expected, these differences are essentially connected with the exclusive diet. While there are many differences of opinion in regard to the ultimate chemical reactions occurring in digestion, the testimony of the most accurate observers is in general agreement in regard to the broad factors.

The Saliva.—The salivary and parotid glands are small and inactive at birth, and the secretion of ptyalin is not definitely established till about the sixth month, though in certain individuals traces of this may be found from birth. Jacobi[1] states that the diastatic ferment is present in the first month, but that the secretion is usually scanty in amount in very young or weak infants. Ptyalin may be found in the parotid gland at birth, and in the submaxillary and sublingual glands about the fourth week, but the saliva has practically no diastatic function until about the end of the first year. Various observers have shown that no constant amylolytic function is possessed by the saliva until about the fourth month.[2]

[1] Jacobi, 'Therapeutics of Infancy and Childhood,' second edition, 1898.

[2] *Vide* Monti, 'Kinderheilkunde in Einzeldarstellungen,' Vienna, 1899; Thomson, 'Guide to the Clinical Examination and Treatment of Children'; and Fenwick, 'Disorders of Digestion in Infancy and Childhood,' 1897.

The chemical action of the saliva is probably in all cases a comparatively unimportant part of its functions, since this action is so brief owing to its neutralization in the stomach. Both in infancy and in adult life the most important function of the saliva appears to be that of moistening and lubricating the mucous membrane of the mouth, and its function is more valuable when mastication becomes necessary. The digestion of starch is carried out in the intestine by the pancreatic secretion. The question, therefore, of the date of the precise appearance of ptyalin is rather of theoretical than practical interest. Even when the amylolytic action is present, as in later years, it is very doubtful if it is of any great service to the individual, since ptyalin can only act in an alkaline medium, and as soon as the food reaches the stomach the acidity attendant on gastric digestion inhibits this action.

The Stomach of the Infant.—The stomach of the infant in early life presents few of the characteristics of the adult organ. The muscular wall is poorly developed, especially in the neighbourhood of the fundus. The relative amount of muscle tissue characteristic of the adult is not reached until about the end of the first year. The cells connected with the secretion of the gastric juice, both the central and the oxyntic, are less numerous, while the mucous glands are more numerous than in adult life.

The position of the stomach in relation to the body is nearly vertical, and the shape, owing to the slight development of the fundus and of the greater curvature, is tubular. Peristalsis is comparatively feeble, but the stomach completely empties itself in about two hours, the greater portion of its contents being disposed of by the stomach under the hour.

Despite the weakness of the gastric muscles, vomiting is more easily effected than in the adult, by reason of the weak resistance of the cardiac sphincter, the tubular shape of the stomach, and the fluid condition of its contents.

Gastric Capacity.—The gastric capacity is of importance in relation to the regulation of the feeding of the young infant; hence, while the rate of peristalsis more or less determines the intervals of feeding, the gastric capacity determines the amount of each feed, since it may be assumed that, generally, the infant is not satisfied until the stomach is moderately distended. The many facts of clinical experience, together with the observations of the size of the stomach, seem to demonstrate very clearly that in the young infant satisfaction of hunger and the filling of the stomach so that it is distended almost to its complete extent, short of dilatation, are practically in close correspondence. The regurgitation of a small amount shortly after a meal must be regarded as the natural ejection of an excess leading to uncomfortable distension; hence the remaining contents may be regarded as representing the gastric capacity, for the time being, of the individual infant.

The actual gastric capacity is probably less than the amount of food taken, for it may be assumed that as food escapes through the cardiac orifice at the end of a meal and is vomited, so the ingested milk during the meal may pass into the duodenum. In the case of infants requiring exceptionally large amounts, this, in all probability, regularly occurs.

No method of estimating the gastric capacity by the quantity of food taken can be regarded as representing the actual capacity, since various factors interfere with the accuracy of the observation. If we take the amount of food ingested at every meal, this is open to the doubt as to whether the full quantity representing the maximum capacity was received by the infant, and, on the other hand, the estimate must be affected by the probability of milk being rapidly poured into the duodenum. Measurements taken on the cadaver scarcely prove the capacity during life.

From investigations carried out on the normal living infant results have been obtained which are sufficiently definite to afford valuable indications as to the normal amount of food required. The practical test is carried out as follows: A healthy mother having plenty of good milk, with an infant of normal size, weight, and appetite, is selected. The infant is carefully weighed, and is then allowed to take the breast until it is satisfied. The infant is then weighed again, and the increase of weight is taken as representing the weight of milk ingested.

This test is far more reliable than the results to be deduced from the examination of the cadaver, for it is practically impossible to determine in the case of post-mortem tests where normal distension ends and dilatation begins. Hence the figures derived from post-mortem results are almost always higher than those recorded by the clinical method.

Rotch has shown the average actual gastric capacity by reference to the actual amounts of milk mixtures taken by a large number of infants. The following figures show the average amounts taken by 774 infants fed from the milk laboratories, from birth to the end of the first year of life:

AVERAGE ACTUAL GASTRIC CAPACITY.

Age.	Ounces.
1 day to 4 weeks, average amount fed	0·988 to 2·355
4 weeks to 8 weeks, average amount fed	2·355 to 3·220
8 " 12 " "	3·220 to 3·969
12 " 16 " "	3·969 to 4·574
16 " 20 " "	4·574 to 5·284
20 " 24 " "	5·284 to 5·719
24 " 28 " "	5·719 to 6·187
28 " 32 " "	6·187 to 6·953
32 " 36 " "	6·953 to 7·544
36 " 40 " "	7·544 to 7·894
40 " 44 " "	7·894 to 8·071
44 " 48 " "	8·071 to 8·231
48 " 52 " "	8·231 to 8·254

In this country the average would probably be somewhat higher, as it is noticeable that in regard to the

average birth weight and rate of gain the healthy American infant appears to be somewhat less vigorous than the healthy English infant.

Growth of the Stomach.—The growth of the stomach is very rapid in the first three months, slow during the next three months, and after this age the capacity gradually increases.

Frolowsky, taking 1 as the figure representing the gastric capacity for the first week, represents its increase as follows:

INCREASE IN GASTRIC CAPACITY.

First week - - -	1
Fourth week - -	$2\frac{1}{2}$
Eighth week - -	$3\frac{1}{5}$
Twelfth week - -	$3\frac{1}{3}$
Sixteenth week - -	$3\frac{4}{7}$
Twentieth week - -	$3\frac{3}{5}$

The rapid increase in the first eight weeks is in marked contrast with the later development.

The age of the infant is, however, an extremely unreliable basis for estimation. The two most constant factors determining the capacity of the stomach are the *weight* of the infant and the *length* of the trunk. It is stated by many authors that the gastric capacity is higher in those infants artificially fed than those that are entirely breast-fed. As Rotch points out, this is an extremely noteworthy observation, since it emphasizes one of the commonest factors in substitute feeding—that of overfeeding. It is difficult to believe that, with adequate substitute food, a greater gastric capacity is required for this than for human milk.

The chief practical points in relation to gastric capacity are:

1. The necessity for frequent increase of amount in the early months.

2. The comparative permanence of capacity during the sixth to the eighth month.

3. The gradual increase of capacity at the end of this period.

In individual cases these rules may be departed from very considerably. Certain infants require much larger amounts than the average in the first three months. These instances are almost invariably associated with digestions only capable of dealing with exceptionally dilute mixtures. It is probable, in these cases, that the food passes more quickly than usual into the duodenum. The demand for a quantity in excess of the average amount is not maintained in the later months.

Gastric Digestion.—The processes of gastric digestion in the infant are related to the character of the diet and the primitive development of the stomach.

In less than a quarter of an hour, under normal circumstances, the whole of the *caseinogen* present in the milk is precipitated in its solid form, *casein*. This precipitation is brought about by the *rennin ferment*, which is constantly present in the infant's stomach already formed. In the adult it only appears to exist in an antecedent condition, and an acid solution is necessary for its development. In the case of the infant the gastric juice is neutral or slightly alkaline at the beginning of digestion, so that acidity of the gastric juice is not necessary for the formation of *casein*. As soon as this coagulation occurs, the ferment secreted by the pepsin cells acts on the casein so as to form soluble peptones. This process is, however, an elaborate one; and it is probable that many organic compounds, representing various complex reactions, are evolved. These changes are so various that there is much difference of opinion amongst observers as to the precise reactions which may be regarded as normal.

Hydrochloric Acid.—The absence of free hydrochloric acid is a striking feature of the gastric contents. This is accounted for to some extent by the comparatively small amount secreted in early infancy, but to a greater extent

by the great affinity of hydrochloric acid for casein and its subsidiary compounds. In virtue of these combinations, a variety of compounds of proteins and chlorine are formed of the nature of amido-acids. As digestion proceeds the hydrochloric acid is disengaged from these compounds, so that towards the end of digestion—that is, in about an hour and a half in quite young infants—a small amount of free hydrochloric acid may at times be present.

Excess of Caseinogen.—When the caseinogen is in excess, the casein is precipitated in the form of large lumps. Not only is the casein too great in amount relatively to the amount of hydrochloric acid secreted, but, owing to its coagulation in large masses, the chemical reactions are extremely imperfect.

The interference with normal digestion is increased by the fat, which, instead of being suspended as an emulsion, becomes entangled in the casein masses, so that these masses consist not merely of casein, but of an extremely indigestible combination of casein and fat.

The digestion is in consequence altogether disturbed and a variety of products are formed, some of them being of an irritant character. The sour vomiting of curdled lumps is a frequent result of these changes.

One of the common faults of milk mixtures modified at home is their indigestibility, owing to the relative excess of caseinogen. For the reason above stated, the interference with digestion is greatly intensified when fat is present in any considerable amount. In consequence of this, home modified mixtures are almost always notably deficient in fat, for it is found that, when a normal amount of fat is given, symptoms of sickness and gastric fermentation ensue. These effects, which are attributed to the fat, are in reality due to the excess of caseinogen interfering with the normal fat emulsion.

Lactalbumin is not precipitated by rennin, and thus remains in solution. In this condition the digestive

glands readily deal with it; indeed, some authorities, notably Brücke, contend that the albumin is absorbed directly by both the gastric and intestinal mucous membranes. Whether this be true or not, there is no doubt that the lactalbumin is highly digestible, and that the difficulty of protein digestion only occurs when, from the excess of caseinogen, the character of the protein differs from that which is normally present in the infant's food.

Phases of Gastric Digestion.—Gastric digestion may be divided into three fairly distinct phases: In the first, the reaction is alkaline or neutral; the caseinogen is formed into casein by the action of the rennin ferment. In the second, which in point of time is not altogether distinct from the first, the casein reacts with pepsin and with the chlorides of the gastric secretion; lactic acid is formed, and the chyme becomes *acid*. In the third stage, gastric digestion and the expulsion of the stomach contents into the duodenum are practically complete, and free hydrochloric acid may be present.

Gastric Absorption.—The amount of food absorbed by the stomach is probably very small. Alcohol is absorbed readily, but water is not absorbed at all. As water enters the stomach, it begins almost immediately to flow into the intestine; the pylorus alternately contracts and relaxes, and with each relaxation a certain amount of fluid escapes into the duodenum. Since the natural diet of the infant consists of nearly 90 per cent. of water, this fact is important.

The Gastric Function.—While certain substances may be absorbed to some extent by the stomach, its chief function is that of a churn in which many chemical processes take place so as to bring the food elements into a condition suitable for intestinal digestion and absorption. The relative size of the stomach and of the intestine clearly points in this direction, while the comparatively small absorptive power of the stomach allows of the

neutralization or rejection of injurious substances before they have time to enter the blood or be passed on to the intestine.

As a result of normal gastric digestion, a food mixture of peculiar character passes through the pylorus into the duodenum. The casein is in the form of small coagulated masses, partly unmodified and partly in various complex forms such as propeptone and peptone. These are mingled with various other bodies, the fatty acids, organic chloro-ammonia compounds, leucin, tyrosin, and carbon dioxide. The fat is unmodified, but some is still in emulsion and some mixed with the clots of casein. The reaction of the mixture is now definitely acid, and this is due to the presence of lactic acid in considerable amount. In this reaction lactose is the primary element.

Intestinal Structure.—In common with the stomach, the intestinal canal of the infant presents some definite characteristics. The development of the muscular wall is poor, and peristalsis is in consequence liable to become slow or irregular. The duodenum is larger, relatively, in the infant than in the adult. Throughout the intestine the mucous membrane is well developed, the villi are highly vascular, and it is rich in lymphoid elements; the nerves are very numerous, though the myelin sheath is imperfect. Lieberkühn's glands are not so numerous as in the adult, but the mucous glands are well developed and secrete plentifully.

Intestinal Digestion.—In the early months, the absorptive power of the intestine is very great, while the secretions necessary to deal with elaborate food products are deficient. Owing to the elaboration of the lacteal system the intestine is able to absorb everything that is required when presented in the form of the natural diet, so that the degree of digestive power requisite in the adult is not called for in the infant. The secretion of the intestinal glands is alkaline; the amount of the secretion depends

to some extent on the acidity of the chyme, for while the secretions from the pancreas and the *succus entericus* itself are alkaline, the contents of the small intestine in normal circumstances are always acid.

Into the second part of the duodenum are poured the bile and the pancreatic secretion. In this latter there are two ferments present from birth—trypsin and steapsin. At about the sixth month amylopsin is present, but before this it is either absent or only exists occasionally and in very slight amount.

The secretion of bile is very free; indeed, this is present from the third month of intra-uterine life; its pigments, bilirubin and biliverdin, are plentiful, but the biliary acids, fat, and organic salts, are much less in relative quantity than in the adult. Bile must be regarded to some extent as an excretion. The antiseptic action attributed to it is highly problematical, but it greatly assists the emulsification of fat by steapsin. Meconium principally consists of biliary substances. Cholesterin, a constituent of bile, is found unaltered in the fæces.

The pancreatic secretion *trypsin* is the chief agent in the digestion of the proteins, while *steapsin* emulsifies the fats so that they are presented for absorption by the lacteals in a very finely divided state. A considerable proportion of fat, however, is not absorbed, and the presence of an excess of fat over the amount demanded for nutrition is necessary in order to maintain the intestinal contents sufficiently soft.

It is probable that many of the processes of digestion and absorption are promoted or assisted by enzymes. Judson and Gittings quote the statements of several observers. Marfan found an active ferment present in human milk capable of breaking up fat, which he termed *lipase*. It was also found to be present, though less active, in cow's milk. The conversion of lactose into lactic acid is attributed to the alleged ferment *lactase*, and

numerous other observers have described ferments with diastatic and other properties. The existence of these bodies as definite ferments is doubtful, since it is probable that many of them are the results of bacterial development. The bacteria throughout the intestinal tract are so numerous that it is impossible that they can live and multiply without being responsible for many chemical changes in the products in which they develop.

Intestinal Excretion.—The intestinal excretion of the infant during the twenty-four hours after birth consists entirely of that peculiar substance to which the name *meconium* is given, and which is never met with except in the case of the fœtus or newly-born infant. In colour it is generally dark olive-green, sometimes being almost black. It is without odour, viscid, and its reaction is slightly acid. It consists of epithelial cells which have desquamated from the intestinal mucous membrane, mucus, bile pigments, together with leucocytes and crystals of cholesterin. Fat is present, and is probably derived from the vernix caseosa. Normal meconium is invariably sterile. The total amount excreted by the infant is usually between 2 and 3 ounces. While the bulk of the meconium is generally passed in about the first two days of life, traces of it may occur for some days, and the motions of the infant do not usually become of the normal character till towards the close of the first week of life.

The typical intestinal dejections of the normal infant are of golden colour ; their consistence is that of soft paste, bearing a close resemblance to the appearance of thinly-mixed mustard. The odour is not very marked, but somewhat resembles that of stale milk ; there is no fæcal odour, and this is not generally manifested until the infant receives food other than milk.

Intermingled in the motions are numerous fine granular

masses, yellowish-white in colour, and composed chiefly of fat. These must not be confused either with the curds present in pathological conditions, when the proteins are in excess of the infant's digestive capabilities, or with the masses of pure fat associated with an excess of fat in the food. Fat, in the form of fat globules, fatty acids, and compounds with lime, is a prominent constituent of the motions. There are also present a great number of bacteria, many of them being directly associated with the processes of intestinal digestion.

The precise character and appearance of the dejections are much modified by the diet. The yellow colour of the motions is due to bilirubin, which in the infant is generally found undecomposed. It may, however, be subjected to oxidation, when the colour becomes greenish-yellow, and it frequently happens that bilirubin changes to biliverdin on exposure to air, so that a normal yellow motion may become green soon after it has been passed.

Dejections of a grass-green colour are definitely pathological, but it must not be assumed that in all cases a green colour is necessarily a sign of disorder. Just as the change of colour occurs in the motion soon after its passage, so the change may take place low down in the intestine, and this appears to be of comparatively frequent occurrence. The first part of a motion may be quite normal, whilst the last part may be green or greenish in colour, and *vice versâ*. Greenish motions are not necessarily pathological. In one case under the author's care the infant's motions were usually partly green and partly yellow in colour. This infant did exceptionally well, doubling its birth weight in four months. Those cases, however, in which the colour is purely green and in which no yellow can be detected are nearly always pathological. The yellow colour is distinctly modified by the amount of fat in the food. A low fat percentage will give rise to motions of quite light-yellow colour, while a high fat per-

centage will cause the dejections to be of a rich yellow, with a tendency to become brown.

The Secretion of the Digestive Glands.—Pawlow[1] has shown that an almost exact proportionate relationship exists between the quantity of gastric juice secreted and the amount and character of the food taken.

Chigin experimented with a diet of raw meat, and he found that for 100 grammes 26 c.c. of juice were secreted, for 200 grammes 40 c.c., and for 400 grammes 100·6 c.c.

Pawlow argues that since the food is made up of several constituents, and since different juices are poured out into the alimentary canal, the supposition appears natural that each fluid, with accentuation of certain of its properties, is furnished chiefly for a particular kind of food.

The influence of the precise quality of the diet on gastric secretion is shown in the ensuing table. A dog was fed first with bread, then with raw meat, then with milk. The amount of gastric juice and its digestive power were noted in each case.

Time.	Hourly Quantity of Juice.	Digestive Power.
	BREAD (200 grammes).	
8-9 a.m.	3·2 c.c.	8·0 mm.
10 ,,	4·5 ,,	7·0 ,,
11 ,,	1·8 ,,	7·0 ,,
	RAW MEAT (200 grammes).	
12 noon	8·0 c.c.	5·37 mm.
1 p.m.	8·8 ,,	3·50 ,,
2 ,,	8·6 ,,	3·75 ,,
	MILK (200 c.c.).	
3 p.m.	9·2 c.c.	3·75 mm.
4 ,,	8·4 ,,	3·30 ,,

These results were confirmed by numerous observations. The *amount* of secretion is greatest for milk, and lowest for bread; on the other hand, the digestive *power* of the fluid secreted is highest for bread and lowest for milk.

1 'The Work of the Digestive Glands,' translated by Thompson; London, 1902.

In regard to the pancreas, the following table shows the results of experiments :

PANCREATIC SECRETION IN RELATION TO THE PRECISE DIET.

Diet.	Quantity of Secretion.	Proteolytic Ferment.		Amylolytic Ferment.		Fat-splitting Ferment.	
		Strength.	Total Quantity of Ferment Units.	Strength.	Total Quantity.	Strength.	Total Quantity.
Milk, 600 c.c. -	48 c.c.	22·6	1,085	9·0	432	90·3	4,334
Bread, 250 grammes	151 "	13·1	1,978	10·6	1,601	5·3	800
Flesh, 100 grammes	144 "	10·6	1,502	4·5	648	25·0	3,600

The fluid secreted in response to milk stimulation has high proteolytic and fat-splitting powers, but the total quantity of ferment units is low. The strength of the secretion in regard to fat is remarkable.

Experimenting with various solutions containing sugar, peptones, etc., Pawlow found them only to excite pancreatic action when the reaction of the fluid was strongly acid. Bayliss and Starling[1] have found that the actual excitant is not the acid itself, but a substance to which they have given the name *secretin*, produced by the action of the acid upon the mucous membrane of the upper part of the small intestine.

In regard to bile the same law was determined. In the fasting animal the secretion of bile is entirely suspended, and only certain substances produce a flow. Experiments with water, acids, raw egg, albumin, etc., showed that none of these cause bilious secretion. But fat, extractives of meat, and the products of albumin digestion set up a free secretion. Pawlow has shown that the func-

[1] *Proceedings of Royal Society*, vol. lxix.

tion of the bile is that of an adjunct to the pancreatic secretion. The enzymes are much increased in power, and this is most noticeable in regard to the fat-splitting enzyme, the action of which is increased two- or three-fold. Probably this is due to the fact that bile arrests the action of pepsin, which interferes with the pancreatic secretion. The same function—that of increasing pancreatic power—has been found in the succus entericus, but here the proteolytic powers are those that are most influenced.

All these observations show conclusively that the process of digestion is a response to stimulus; that in the absence of the proper stimulus the activity of the glands is inhibited; and clinical evidence clearly demonstrates that when the stimulus is continuously withheld for a sufficiently long period complete atrophy of the secretory functions ensues.

CHAPTER XI

THE DIET OF THE INFANT IN RELATION TO GROWTH AND HEALTH

THE young infant, by reason of its rapid growth, requires a diet different both in its character and in its constituents from that of the child or the adult.

The Diet required for Structure.—The fact that by the fifth month the infant, in normal circumstances, at least doubles its birth weight and by twelve months of age at least trebles its original weight shows development to be proceeding at a very rapid rate. Hence the first essential of the diet is that it should be of a character to meet the requirements of this rapid creation of new tissue. While in the adult food is required chiefly as fuel to be converted into energy, and, secondly, as building material to repair waste, in the infant the building up of a new organism is the prime factor. Upon the character of the materials supplied for this purpose depend the final structure of brain and liver, bone and muscle.

In the adult any deficiency or excess of nutritive material in a single meal is of comparatively small importance. The error is corrected by the variety of diet, and since structure is complete, where disorder results it finds its chief expression in digestive disturbance and general impairment of health. In the infant, any defect is immeasurably magnified by the practically constant character of the diet.

Effects of Imperfect Methods.—If the food does not accord with physiological requirements, there is little if any opportunity for compensation of the error. So far from the deficiency in a given element during one day being compensated for by a comparative excess on the following days, the probabilities are that the defect is intensified by a continuance of the same conditions. In the practice of substitute feeding, every mother or nurse relies upon some method of modifying cow's milk, and this particular practice, whatever its precise character may be, is carried out with but slight alterations throughout the most vital period of the infant's life. This emphasizes the extreme importance of insuring that the food administered is one answering all requirements.

Probably the commonest deficiency in the ordinary domestic milk mixtures lies in the extremely inadequate amount of fat present. These mixtures are frequently found to contain only about 1 per cent. of fat instead of the normal 4 per cent. The effects of this defect are often insufficiently realized. In the case of an infant receiving the normal quantity of fluid at the usual intervals, the deprivation of fat, when the mixture contains but 1 per cent. of this constituent, would amount, approximately, in six months to over thirteen pounds of pure fat. The effects of such a deprivation occurring at such a vital period of development must necessarily have a profound influence on the tissues.

The attitude of those responsible for the care of the infant is often one in which all such considerations are ignored, and they are quite content when the mixture satisfies the first requirement only—namely, that it is tolerated by the infant's stomach. Indeed, many of the most inadequate mixtures are made use of as a result of this attitude.

When a mixture of equal parts of cow's milk and water is given to the infant, it frequently causes severe gastric

and intestinal disturbance, due to the excessive amount and improper character of the proteins present. In order to reduce the proportion of these, the milk is further diluted to, for instance, one part of milk with two of water. If this succeeds, then the infant's digestion has been to some extent met at the expense of its nutrition, for in the first dilution the fat was already deficient, and in the second it has been reduced to but a fraction of that required.

The dietetic problem of infant feeding is a twofold one: To provide the infant with (1) an adequate supply of the materials physiologically necessary, (2) in a form capable of being digested and absorbed. It cannot be solved when either of these two essentials is neglected.

In reference to defective nutrition, two groups may be broadly distinguished: Those primarily affecting structural growth and development, and those primarily affecting the digestive system. In the presence of acute disorder of the digestion, it may be necessary for the time to exclude the wider considerations till the acute local symptoms have been treated. But the aim of the physician must always be to provide the infant with a food that is readily digested, and in kind and quantity adapted to the requirements of normal development.

Pathological features occurring in the course of growth arise chiefly from deficient intake of essential material. Excess of food, or the presence in the diet of improper materials, gives rise primarily to disorders of the digestive system, though, as a later result, these may be followed by systemic defect. Very frequently in the food of the infant deficiency of necessary material coexists with the presence of injurious foreign matter.

Those faults affecting structure are the more serious since the resulting defects in the bone, brain, and the various organs only gradually become definitely established, so that great harm may be done before the injuries

are so manifest as to be recognizable by inspection and palpation. Comparatively slight intestinal disorder immediately provokes, or should provoke, comment. Such disorder is seldom insidious either in its onset or symptoms.

In correspondence with the rapid anabolism of the infant, the diet must contain a much greater proportion of the tissue-builders than the diet of the adult, while, as the muscular activity is for some time very limited, the energy-producers are required in less proportion. These factors find their practical expression in the relative composition of human milk.

Limitations of the Infant's Diet.—The proximate principles of food consist of water, albuminoids, carbohydrates, fats, and salts. The limitations as to the precise form of these constituents in regard to the infant are much more severe than in the adult. For the adult the albuminoids include extremely numerous varieties, and the source of his carbohydrates is almost equally varied; for the infant the kinds are precisely limited to those found in milk, and are practically confined to two forms of albuminoid material in certain proportions and to one form of carbohydrate.

Water.—More than three-fourths of the whole body consists of water, and it constitutes nearly 90 per cent. of milk. Its function is that of a solvent and diluent, essential to all the chemical processes associated with life. A sufficient amount is necessary for the circulation and the activity of the cells.

In the stomach it prevents the undue concentration of food, and is of great importance in keeping the intestinal contents sufficiently liquid, so as to permit of their free evacuation. In many diseases — especially in rachitis, where the sweating is frequently excessive—in cases where the temperature is raised, and in marasmus, to keep the blood as fluid as possible, the need for water is great,

and this should always be freely supplied. The emaciation and collapse which so rapidly ensue in the diarrhœa of enteritis are largely due to loss of fluid.

The need for water is often shown by the infant in the first day or two of life, before the mother is able to furnish it with milk. Infants frequently suffer considerably from this lack of fluid, and are easily satisfied with a little water given by a spoon. The relatively great body surface of the infant also points to the need for a plentiful supply of fluid, since so much is lost in perspiration.

Uric acid staining is frequently a marked feature of the urine in the early days of life, and is an indication that the infant has not received a sufficient supply of water to enable the kidneys to perform their functions perfectly. Uric acid infarcts in the kidney are of not very uncommon occurrence, and, generally speaking, the urine in the new-born infant is characterized by its high specific gravity. Renal colic from the same cause may arise, though, as a rule, in very young infants it is usually impossible to diagnose such a cause with certainty; but in those cases where there is evidence of acute suffering in the first forty-eight hours after birth the possibility of this should be remembered.

The author invariably provides for this necessity of the infant by the supply of a very dilute milk. As a rule it is taken with avidity, and this desire of the infant may be accepted as a physiological indication of its need.

In the first forty-eight hours of life, the need of the infant is for water rather than for milk, and this want of the infant appears to be frequently unrecognized. Almost the whole of the nitrogenous waste and its derivatives are excreted by the kidneys, and, as many of these are but sparingly soluble, water in plenty is a necessity. It is also requisite for the normal circulation of the blood, lymph and chyle.

In gastric digestion water plays an important part. The

secretion both of pepsin and of hydrochloric acid is only fully accomplished when this is present in normal amount, and the chemical changes prior to absorption cannot be carried out without the free supply of a neutral solvent.

The Proteins.—In the structure of all living cells, protoplasm is the primary feature, and, while it is impossible to state the exact nature of protoplasm, since this only exists in the living form, the proteins are invariably obtained when dead protoplasm is analyzed. In common with all animals, and in contrast with the vegetable kingdom, man is unable to construct protein from its constituent elements, and must be supplied with this already manufactured. And, in contrast to the adult, the proteins suitable for the infant are practically limited to caseinogen and lactalbumin.

Chemical Composition of Proteins.—In the present state of our knowledge no definite chemical composition can be assigned to proteins; that is, they cannot be represented by any formula indicating their molecular composition. On the other hand, their general percentage composition invariably lies within certain limits. The figure of Hoppe-Seyler and Drechsel have been generally accepted as indicating their composition.[1]

	Hoppe-Seyler.	Drechsel.
Carbon	50·0 to 55·0	50·0 to 55·0
Hydrogen	6·9 to 7·3	6·8 to 7·3
Nitrogen	15·0 to 18·0	15·4 to 18·2
Oxygen	20·0 to 23·5	22·8 to 24·1
Sulphur	0·3 to 2·0	0·4 to 5·0

The above table shows that in the primal elements constituting protein there is comparatively little variation. But, in addition to these elements, the various forms contain varying amounts of mineral acid combined with metallic basis. Potassium, sodium, calcium, magnesium, and iron,

[1] Quoted from 'The Chemical Basis of the Animal Body' (Sheridan Lea).

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are present in combination with carbonic, phosphoric, and sulphuric acid. Indeed, there is some reason for supposing that, in the living condition, the proteins are present entirely in combination with salts, the combination, however, being broken up either by the death of the tissues or by the methods employed in the analysis.

Classification of Proteins.—The careful experiments and researches of many observers have enabled us to appreciate the fact that there are essential differences, both physical and chemical, in the constitution of various protein materials. Sheridan Lea[1] has classified the proteins into certain groups, of which the following are of interest in the present connection:

1. *Native Albumins.*—Soluble in distilled water. Solution coagulated by heat, especially in the presence of dilute acid. Not precipitated by alkaline carbonates or by sodium chloride. Lactalbumin is an example of this class.
2. *Derived Albumins.*—Insoluble in distilled water; soluble in acids and alkalies. Not coagulated by boiling. Caseinogen belongs to this class, though differing in some respects from the other members.
3. *Globulins.* — Insoluble in distilled water; soluble in dilute saline solutions. Readily precipitated by saturating their dilute saline solutions with sodium chloride or magnesium sulphate. Lacto-globulin belongs to this class.
4. *Fibrins.*—Insoluble in water; soluble with difficulty in strong acids.
5. *Coagulated Proteins.* — Products of the action of heat on Classes I and 3. The albumin in boiled or sterilized milk belongs to this group.
6. *Albumoses and Peptones.*—The peptones are extremely soluble in water. They are not precipitated by acids, alkalies, or by neutral salts. Some of the albumoses are readily soluble in water, others are less soluble. They are precipitated by saturation with neutral ammonium sulphate.

Though we are not able to determine the precise nature of the chemical differentiations which account for these

[1] *Op. cit.*

widely differing reactions, we can at least appreciate the fact that these reactions must be represented by definite differences of composition. The greater our ignorance is on these points, the more must we be bound by the limitations of observed facts. It cannot be disputed that marked differences, both in regard to physical properties and chemical composition, are exhibited by the bodies belonging to the protein group, and that, for instance, the differences between caseinogen, lactalbumin, and other forms of protein, are scarcely less than the differences between many bodies completely distinguished from one another in chemical nomenclature. Thus, in relation to infant feeding, the term 'protein' is not sufficiently precise or sufficiently exclusive. The forms found in human milk must alone be the criterion in relation to the young infant.

The Effects of Deficient Protein.—A deficiency of protein in the diet affects the whole of the tissues, and the general character of the injuries resulting from this deprivation is essentially the same in all the organs. Since these defects are not usually recognized till they have passed from the microscopic to the macroscopic, the management of the diet must here be eminently prophylactic in order to ensure the supply of a normal amount in the food mixture. For a time, the infant may maintain a surprising amount of vigour together with increase of weight on a diet rich in carbohydrates but deficient in proteins. This is notably the case with some infants fed on the ordinary sweetened varieties of condensed milk. The extremely pernicious results are well recognized at the Infants Hospital, so much so that the 'condensed-milk' baby is quite a defined clinical entity.

The absence of the proper amount of protein is seldom the cause of digestive disturbance, since in the ordinary milk mixtures it is the albuminoids which most commonly give rise to difficulty, owing to the excess of caseinogen

and the deficiency of lactalbumin. In home modification the tendency is either towards an extreme dilution of the milk to overcome the difficulty caused by the disproportionate amount of caseinogen, or some patent food is resorted to.

The baby so often put forward as the picture of health is very commonly found to be extremely fat and chubby, but the actual condition of the infant tells a very different tale to the experienced observer. These cases frequently present undoubted signs of rachitis well established, but the infants are generally too young to show the gross lesions of bone which must inevitably appear later. Hence they are regarded as healthy, and the excessive amount of fat, generally due to a great excess of carbohydrates, is almost universally regarded as a particularly good sign, whereas it is in fact quite pathological, and is almost invariably associated with a markedly atonic condition of the muscles, ligaments, and other tissues.

When the protein-supply has for some time been deficient, the effects are widely distributed. The blood is affected very early, its specific gravity is diminished, and the hæmoglobin falls rapidly, often falling below 50 per cent. of the normal amount.

The red cells are also diminished in number. In cases which are at all severe these cells are much changed in form and size (poikilocytes), while nucleated red cells (hæmatoblasts) are present, and the leucocytes are generally increased in number.

These profound changes in the character of the blood are attended by numerous changes in the whole of the tissues. It is probable that the blood is first affected, and that the signs and symptoms are primarily dependent on the alteration in the blood. It may be, however, that the primary affection begins in the bone-marrow and spleen. When the anæmia is established the infant

is pallid, the muscles are soft and very atonic, the normal growth of bone is greatly altered, the cerebral and spinal nervous system is unstable, and the manifestations of pathological irritability and fretfulness are frequent. Severe headache and pains in the limbs are not infrequently met with. On auscultation of the heart, hæmic murmurs may be heard, and œdema of the tissues occurs in some cases.

Effects of Excess of Protein.—An excessive amount or a wrong type of protein is one of the commonest causes of serious gastric and intestinal disturbance in the young infant. Frequent vomiting, colic, flatulence, with green offensive motions, are some of the more prominent clinical signs. Constipation may be present at first, but when the excess is great the irritation generally leads to the onset of diarrhœa. It is important in these cases that the defect in the food should be dealt with; but when the intestinal disorder is severe it is not only the food that has to be altered. The stomach and intestine are in a pathological condition by reason of the chemical changes occurring in the masses of undigested albuminoid material, and this requires appropriate treatment before the normal diet of health can be digested and absorbed. Moreover, it may be a *qualitative* excess with which we have to deal rather than a *quantitative* excess. The following case illustrates this:

An infant, three months old, had been suffering for some time from vomiting, colic, and alternation of constipation with diarrhœa accompanied by green and offensive motions. During the last week the infant had become much worse, and had lost 8 ounces in weight. The author was then consulted in reference to the case. It was evident that the food supplied was responsible for the condition. The mixture used was a domestic modification of cow's milk. A feed was made up by the nurse, and this was analyzed. The analysis of the specimen showed the following composition:

	Per cent.
Fat - - - -	1·15
Sugar (chiefly cane-sugar)	8·50
Albuminoids - - -	1·20

The stomach was washed out; castor-oil (2 drachms) was administered, and this was followed by three doses of calomel ($\frac{1}{6}$ grain). During the first two days after the treatment the infant was fed on a milk according to the following prescription :

	Per Cent.
℞ Fat - - - - -	2·50
Lactose - - - -	5·50
Whey proteins - -	0·50
Caseinogen - - -	0·25
Lime-water - - -	5·00

Heat at 150° F. Eight feedings, each containing 4 ounces.

The infant rapidly improved, and the mixture was strengthened in all its elements. At the end of a week the infant was taking well, and making very satisfactory progress on, the mixture according to the prescription following :

	Per Cent.
℞ Fat - - - - -	3·50
Lactose - - - -	6·50
Whey proteins - -	0·75
Caseinogen - - -	0·50
Lime-water - - -	5·00

Heat at 150° F. Eight feedings, each containg 4 ounces.

This case well illustrates the fact that the mere amount of protein only constitutes one of the factors. Within a week of the illness the infant was digesting well a mixture containing an amount of protein slightly in excess of the amount in the domestic mixture, but differing greatly from it in quality, owing to the predominance of the whey proteins.

In breast feeding much disturbance is caused by variations occurring in the protein content of the milk, calling for careful management of the mother in regard to both diet and exercise. These factors have been discussed in reference to the management of lactation. Intolerance of caseinogen is the chief characteristic of digestive disorders arising from the proteins. In substitute feeding, this difficulty should be met by supplying the requisite amount

of protein in the form of whey proteins combined with but a small proportion of caseinogen.

Fat.—The part played by fat is one that is frequently overlooked in the feeding of infants, and its deficiency is the explanation of much disorder and disease. With the onset of disorder in the nursing mother, the fat is at once affected, and the rapid deterioration of human milk in this respect is very striking. In the cow, the proportion of fat in the milk is about the same as in human milk; but cow's milk as usually sold contains less fat than the human standard. The artificial foods, while they possess almost innumerable faults and contain much excess of certain constituents, are invariably deficient in this important element.

The maintenance of the normal degree of animal heat is of the first importance in the young infant. In many cases, especially in ill-health, the loss of heat is greater than the heat produced, and, in consequence, all the functions are interfered with. The extremities naturally show the most marked evidence of this loss of animal heat, so that 'cold feet' is one of the cardinal signs of the condition.

The limited amount of muscular exercise of which the young infant is capable renders it exceptionally dependent upon its food as the heat-producer, and thus upon those constituents connected with this function — fat and lactose. Of these, fat is much the more powerful of the two in the production of heat. In human milk the proportion of fat is nearly three times as great as the protein elements.

Fats are deficient in oxygen, but rich in carbon and hydrogen, which both have a very great affinity for oxygen. In lactose the amount of carbon is nearly equalled by that of oxygen, as is seen by its formula—$C_{12}H_{22}O_{11} + H_2O$. The chief fats in human milk are compounds of glycerine, with oleic acid, palmitic acid, and stearic acid, forming

olein, palmitin, and stearin. The large amount of carbon available for oxidation is shown by their formulæ:

Olein - -	$C_3H_5(C_{17}H_{35}CO.O)_3$
Palmitin -	$C_3H_5(C_{17}H_{31}CO.O)_3$
Stearin - -	$C_3H_5(C_{17}H_{35}CO.O)_3$

These formulæ demonstrate how essential is fat to the organism, and especially to the infant. It presents carbon in an unoxidized, but highly oxidizable, condition, whereas the carbon presented in the form of carbohydrates is already highly oxidized, and is therefore of little avail for chemical combination with oxygen.

But it cannot be assumed that this oxidation of carbon is a simple chemical process of combination so as to form carbon dioxide. This is the ultimate result of elaborate processes, in the course of which almost innumerable products essential to the organism are evolved. The majority of these products are combinations of fat and protein in the shape of complex nitrogenous fats. Lecithin ($C_{44}H_{90}NPO_9$) occurs in the red corpuscles and bile, while it is an important constituent in the brain, nerves, and white blood corpuscles. Cerebrin ($C_{17}H_{33}NO_3$), an important constituent of the brain and nervous system, is another example of the kind. The essential feature of fat is illustrated in the part played by the stearin of human milk in reference to lecithin:

$$\underset{\text{Lecithin}}{C_{44}H_{90}NPO_9} + 3H_2O = 2\underset{\text{Stearic acid}}{C_{18}H_{36}O_2} + \underset{\text{Glycerin-phosphoric acid}}{C_3H_9PO_6} + \underset{\text{Cholin}}{C_5H_{15}NO_2}.$$

These chemical facts are especially important in reference to the effects on nutrition of a diet deficient in fat. The results of chemical analysis and clinical observation confirm each other.

Neither adipose tissue nor the complex nitrogenous fats are necessarily directly derived from the fat supplied as food. Many experimental observations have been made

which go to show that adipose tissue may be derived from both protein and carbohydrate. Clinical observations show most definitely that the deposit of adipose tissue is more likely to occur on a diet deficient in fat, but containing an excess of carbohydrate.

Specific Effects of a Deficiency of Fat.—Deficiency of fat in the infant's diet leads to serious results. The insufficient heat generated has already been referred to, and this may contribute towards the other effects. Though, in the etiology of rachitis, many other factors play their part, the absence of sufficient fat in the diet is one of the predominant causes. There are also numerous symptoms in the alimentary tract due to the same cause. Constipation is usually present, associated with a somewhat chronic indigestion, as indicated by gastric and intestinal pain in the intervals between feeding. The symptoms are not, as a rule, acute, and consequently may fail for some time to attract any marked attention.

The course of the general development is slow, teething is delayed, the mental faculties are feeble, and the brightness and intelligent appearance of the healthy infant are absent. Speech is consequently delayed, and, in general, the faculties of perception and observation are imperfectly developed.

There is good reason for thinking that many of the neuroses in children and adults owe their origin to defective diet in infancy, and especially to the fact that the nervous system has suffered in consequence of the inadequate amount of fat in the diet. While protein is the foundation material of structure, fat plays a potent influence in regard to the specialization of structure. When protein is present in normal amount and fat is deficient, the effects are seen in the more specialized tissues. The development of the teeth is directly affected, so that the first dentition is late in appearance and pathological features are evident. The development of bone

at the epiphyses becomes markedly perverted from the normal standard, so that there is an abundance of badly-formed tissue in these situations.

The high development of the physiological structures for the absorption of this element in the infant and the large amount present in human milk are both facts indicating strongly the physiological necessity. Ninety per cent. of the fat taken is absorbed by the intestinal villi, and the surplus is of importance in affording a lubricant facilitating the expulsion of the fæcal matter.

When the fat in the diet is not merely deficient, but so small in quantity as to be less than one-third of the proper amount, the signs are more acute, and the wasting and weakness are usually pronounced. In these cases the development of rachitis is almost certain if the defect is not speedily corrected.

Excess of Fat.—Effects due to the excess of fat are occasionally met with. Sickness soon after feeding, and diarrhœa with green motions, are the commonest symptoms associated with this. It has already been remarked that a high fat and high protein content tend to be antagonistic. In these cases the symptoms may disappear on a reduction in the amount of the proteins.

A serious excess of fat in the food of the infant is extremely dangerous. A healthy infant requires not less than 3 per cent. of fat and not more than 4 per cent.

When the amount of fat reaches 6 or 7 per cent. the effects may be most serious, and death may occur in a few days from acute fat intoxication. The author is acquainted with several cases where death has either occurred or has been an imminent possibility, and where the cause has been entirely an intoxication arising solely from marked excess of fat in the food. The nature of the symptoms may be partly realized from the fact that in all these cases the diagnosis suggested by the medical attendant was meningitis.

Severe constipation is the first symptom. In cases where the excess of fat is relative (that is to say, is more than the intestine can absorb, while still below 5 per cent.) the intestinal dejections are usually increased in number; but in cases where the amount of fat is grossly excessive, diarrhœa very seldom occurs. The combination of the excessive amount of the fat with the precipitated casein gives rise to the formation of a pasty, putty-like mass which is quite impervious to the digestive processes, while the greasy tenacity of the mass seriously impedes or completely defeats all the peristaltic efforts of the intestinal wall to remove it. As a result there is a partial or complete intestinal obstruction, and reflex vomiting of thin watery fluid occurs. The characteristic of the vomiting is that it occurs some two hours after food has been administered, and is due to reflex irritation set up by the chyme reaching the intestine, and being unable to proceed farther owing to the obstruction. The appearance of the infant is quite characteristic. The skin is white, so that the blood-tint in the cheeks and ears is entirely lost. The infant seems to be swollen, as indeed it is, the blood and the tissues being engorged with fat. The complexion is waxlike. The infant refuses food, is extremely drowsy or partially unconscious, there is usually marked strabismus, and convulsions occur from time to time. The first thing in such cases is to obtain the speediest evacuation of the whole of the intestinal tract. Castor-oil should be promptly administered, and should be followed by colon irrigation to assist peristalsis. For some twenty-four or forty-eight hours after the evacuation the infant is extremely drowsy, and may sleep uninterruptedly for abnormal periods. The food for two or three days should be very dilute, and should be practically devoid of fat. The above description refers to the most serious cases of fat-poisoning. In the milder cases chronic vomiting of undigested masses of

food associated with constipation and a distaste for food are the usual symptoms. In view of the symptoms described, which are liable to develop with considerable rapidity, signs pointing to excess of fat in the diet should receive immediate attention. In the author's experience, the danger of intoxication only occurs when constipation is present. So long as the intestines are acting freely the excess of fat is eliminated.

In infants recovering from severe malnutrition fat-intoxication is a danger which should always be watched for, as such infants may be intoxicated by a comparatively low proportion of fat. Some years ago the author had under his care a remarkable case. The infant had been entirely breast-fed, but at ten months of age only weighed 5 pound 14 ounces. The mother's milk was extremely poor in all its constituents, and contained but a fraction of the normal amount of fat and proteins. The infant flourished in the hospital till it had reached nearly 10 pounds in weight, and was taking a mixture containing 2·50 per cent. of fat. Symptoms of acute fat-intoxication suddenly developed, the weight rapidly fell, and the infant died within a few days of the first sign of the affection.

The following case affords an effective illustration of the rapidity with which the symptoms develop:

A. C. (R. 1879).—Female infant, aged twelve and a half months, admitted September 6, suffering from atrophic enteritis. The infant gradually made a good recovery. On November 30 she was doing well, and had gained 20 ounces in the previous fortnight. She was receiving a milk mixture containing fat 3·50, lactose 4·00, proteins 2·25, supplemented by two rusks per diem, and had received the same food for the previous fortnight. On December 1 she showed distaste for food, and vomited in the night. There was no action of the intestines. The temperature rose to 103·6° F., and in the early morning of December 2 she was extremely ill. She lost $1\frac{1}{2}$ pounds in a little over twenty-four hours. A dose of castor-oil was given; the milk was entirely suspended, and albumin-water was given for twelve hours. A dilute mixture containing fat 1·00, lactose 5·00, proteins 0·75, was then given. She made a good recovery.

On January 8 the fat was raised to 3·00 per cent.

On January 10 the temperature rose to 99·8° F.; she refused food and looked very white. Milk was stopped for a few feeds, and was then resumed, but with only 2·00 per cent. of fat. The symptoms, which on this occasion were slight, rapidly disappeared.

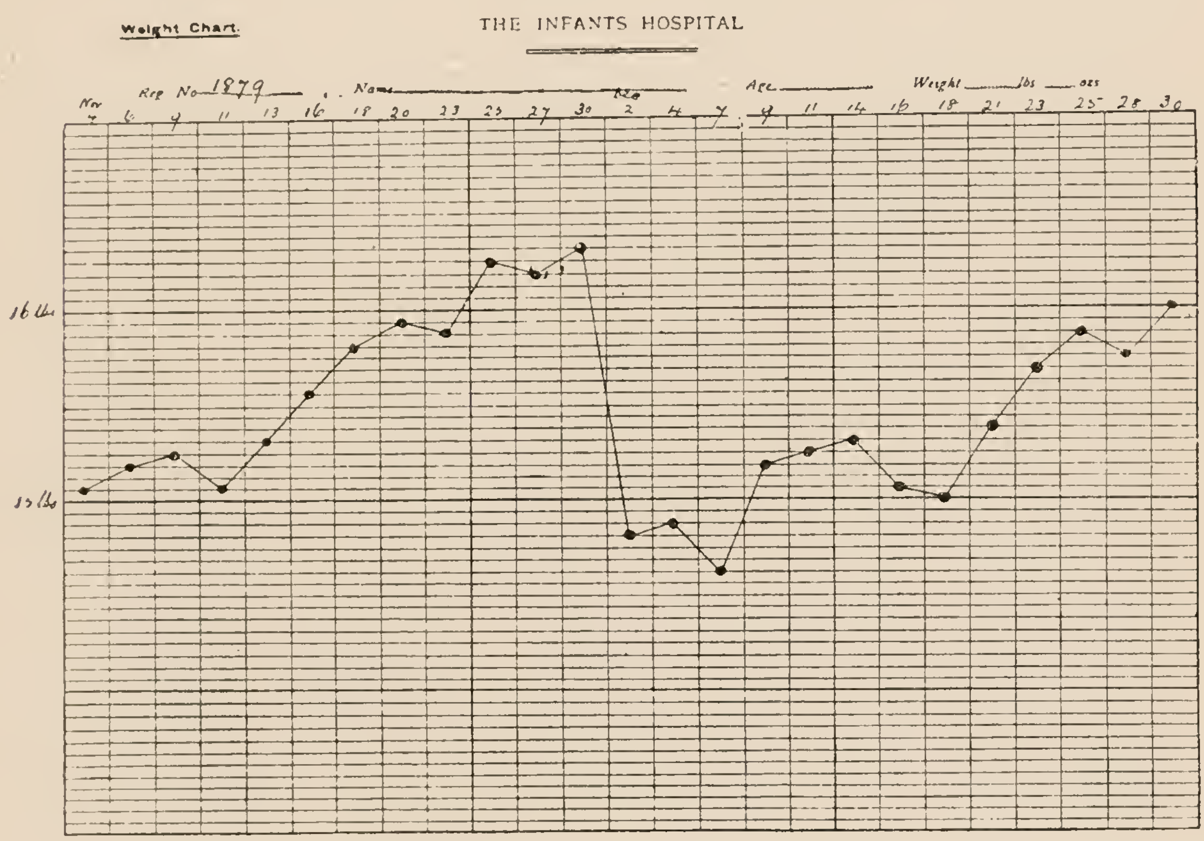

FIG 42.—ACUTE FAT-INTOXICATION. WEIGHT CHART.

Lactose.—Lactose is the only form of carbohydrate present in milk, and is therefore the only form suitable for the normal infant. Other forms of sugar (cane-sugar, maltose, glucose, etc.) are very largely used in place of lactose, and give rise to a great deal of intestinal disturbance. The chemical properties of milk-sugar are peculiar to itself. It plays an essential and important part in the production of lactic acid; without it the lactic acid bacilli cannot act, and the normal processes of intestinal digestion are altogether perverted.

Butyric acid fermentation may take place in the case of starch, dextrins, cane-sugar, etc. Lactose does not undergo this change under normal conditions. Cane-sugar undergoes alcoholic fermentation, but yeast has no

action on milk-sugar. Cane-sugar, maltose, etc., favour putrefactive changes, with decomposition and pathological fermentation of the intestinal contents. Lactose is incapable of these reactions, and by its co-operation with the hygienic bacilli possesses a function directly antagonistic to putrefactive changes.

The production of lactic acid is, as has been explained, not due to the action of the digestive secretions, but to the action of the lactic bacteria upon the lactose supplied in the diet. The reaction is represented by the following equation :

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O = \underset{\text{Lactic acid.}}{4C_3H_6O_3.}$$

Without the presence of this form of sugar in due amount perversion of the digestive processes must arise.

Symptoms of intestinal irritation, in the shape of diarrhœa and of skin eruptions, are frequently seen in infants when their diet contains cane-sugar or maltose and other forms of carbohydrate. Certain preparations containing a large amount of maltose are particularly associated with these disorders. Occasionally lactose may be actually or comparatively in excess, and this may give rise to diarrhœa. This is, however, rarely seen, as it is not a common result of a trifling excess, and cases where lactose has been given in an abnormal amount are uncommon.

CHAPTER XII

THE NORMAL DEVELOPMENT AND THE GENERAL EXAMINATION OF THE INFANT

In order to arrive at a right estimate of the condition of an infant, it is necessary that the degree of development proper to the particular age should be determined as accurately as possible. The rate of growth and the many changes that take place in the young infant are so peculiar to this period of life that these factors need special attention.

The Weight of the Infant.—The weight is one of the most valuable criteria, and is so important that a careful and systematic weight record should be kept whenever practicable. When this is done it enables those responsible for the care of the infant to assess the comparative progress, or warns them of the possibility of some defect or disorder. For a few days after birth, a loss of weight occurs as a result of the voiding of meconium and urine, while the infant is taking practically no food. This loss of weight may largely be prevented, and the vitality of the infant more promptly established, by providing the infant with suitable food. When this is done the loss of weight is very slight or inconsiderable, so that by the end of the first week of life an appreciable gain on the birth weight has been made. Where this is not done the original weight is not regained till about seven days after birth.

In the case of the vigorous infant the preliminary loss

of weight does no harm. In infants with any degree of immaturity everything possible should be done to prevent loss of weight and to establish metabolic equilibrium.

During the first two months, the daily gain should not be less than two-thirds of an ounce. Cases where the gain only amounts to half an ounce or less per diem must be regarded as unsatisfactory and call for investigation, due allowance, however, being made for the circumstances of the particular infant. The following table shows the average increase in weight of the infant:

Average Increase in Weight during the First Two Years.

Weight at	birth	8	pounds.
,,	five months	16	,,
,,	one year	21	,,
,,	fifteen months	24	,,
,,	two years	38	,,

These are figures derived from a large number of cases, which include many below the standard of perfect health. Vigorous infants well fed and cared for frequently develop at a much greater rate than that shown in the above table. The author has had under his observation many cases illustrating this. One infant weighed at birth 7 pounds 13 ounces, and exceeded 21 pounds in weight at the end of six months. It was substitute-fed, by prescribed mixtures, from birth.

In eleven cases where the author was able to make continuous observations from the time of birth to twelve months of age, and where the infants had been substitute-fed throughout, the rate of progress was such that the weight at one year of age was nearly four times that at birth. The following table shows the average of these cases, and affords a much better indication of the standard to be adopted in appraising the character of development of the young infant:

AVERAGE INCREASE IN WEIGHT DURING THE FIRST TWELVE MONTHS OF ELEVEN INFANTS SUBSTITUTE-FED THROUGHOUT.

Weight at birth	-	$7\frac{3}{4}$ pounds.
" five months	-	$19\frac{1}{2}$ "
" twelve months	-	27 "

The Weight Record.—In recording the weight of the infant, a weight chart, corresponding somewhat to a temperature chart, may be used. The chart used in the Infants Hospital is simply a series of ruled lines, each line representing 1 ounce. Thicker lines represent the

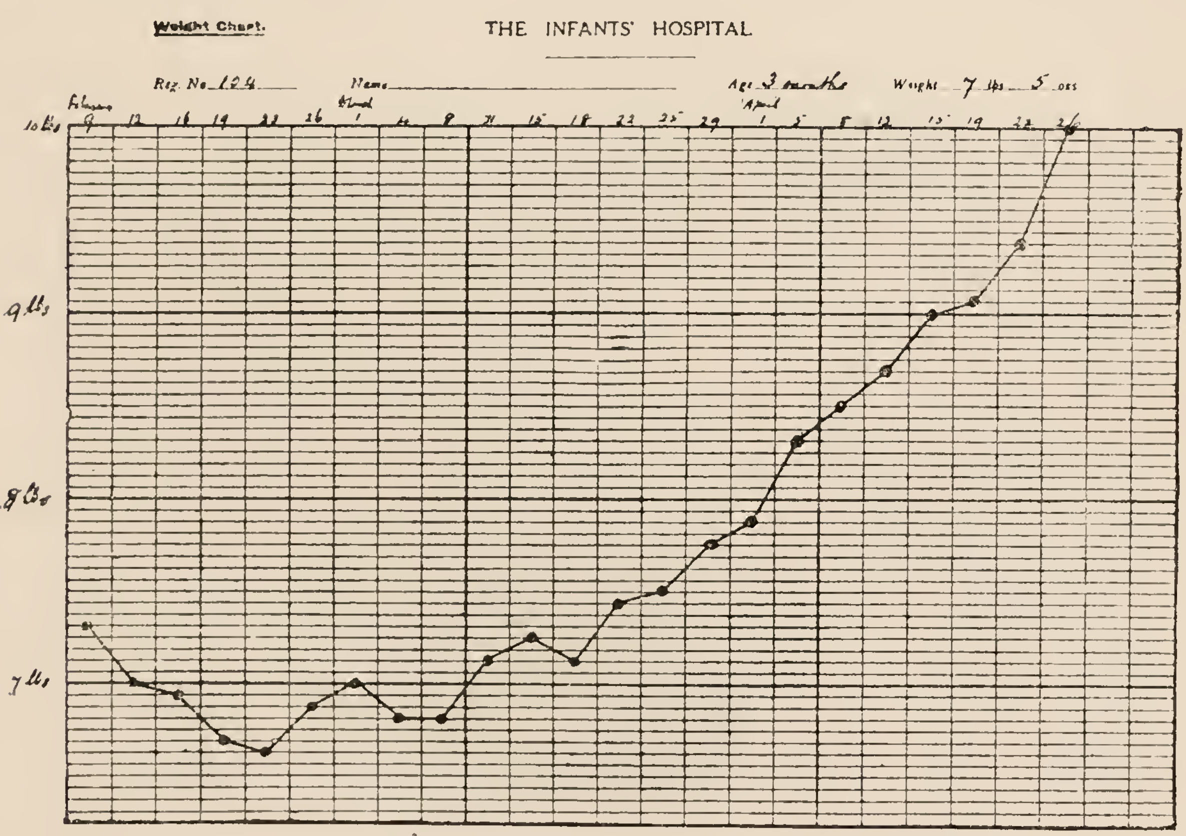

FIG. 43.—THE WEIGHT CHART. (Greatly reduced.)

divisions into pounds, while vertical lines indicate the dates of the various weighings. As most infants lose weight immediately after admission, the lowest section is reserved for these records. It will be observed (Fig. 43) that no specific weights are printed on the margin. This allows the same chart to be used for all infants; it also renders the whole chart available for the weight records of each infant.

The most convenient form of weighing machine is that

illustrated in Fig. 44. Whether it is as exact as other forms may be doubted, but this is of slight importance when the same machine is always used, and this should be insisted upon. The infant should be weighed at the same time of the day on each occasion. This is preferably after its bath, and it should be wrapped in a blanket the precise weight of which is known.

Some care is necessary to ensure that the observation is taken with sufficient accuracy to be of use. Insufficiently trained nurses are notably careless in this respect, and

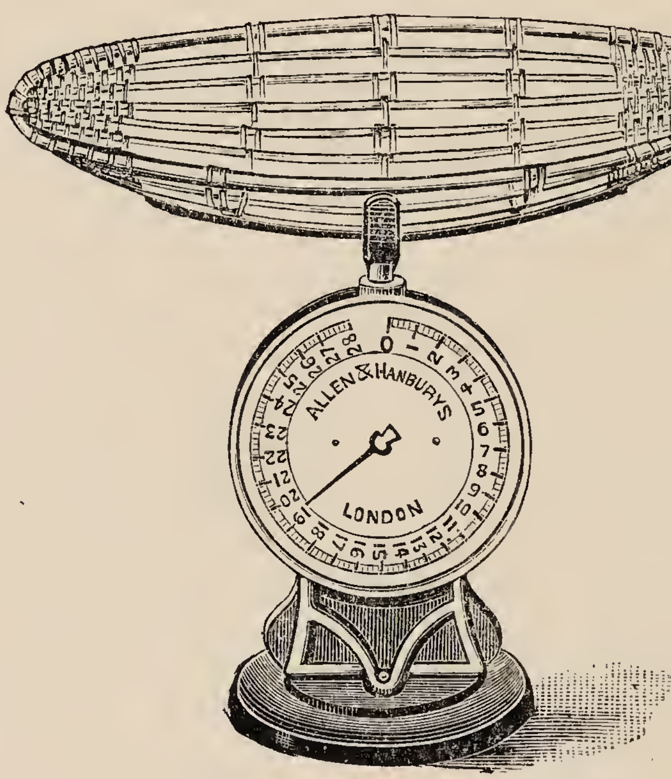

Fig. 44.—Weighing Machine.

exhibit a marked tendency to estimate the weight of the receiver and to neglect other necessary precautions.

The Length of the Infant.—Many other factors besides the increase of weight illustrate the rapid development occurring during infancy. The length of the normal infant at birth when at full term and well developed is 21 inches. In the first six months this is increased by about 5 inches, or nearly an inch a month. During the following six months the growth is slightly less rapid, amounting to about 4 inches. The figures representing the increase of length

during the period of rapid development are approximately as follows:

THE AVERAGE INCREASE IN LENGTH DURING THE FIRST THREE YEARS.

Length at birth	- - -	21 inches.
,, six months	- -	26 ,,
,, one year	- -	30 ,,
,, two years	- -	33 ,,
,, three years	- -	36 ,,

The length of the infant is one of the most important factors in diagnosis. Immature development, whether arising from prematurity or other cause, is invariably associated with deficiency in length. Infants under 19 inches in length at birth are seldom reared. Infants under 20 inches in length are suffering from congenital defect, and many of these do not live long. A deficiency of even half an inch is by no means to be ignored, since it is always an indication of some degree of immaturity. The measurement is taken from the occipital fontanelle. The tape is passed along the occiput down the middle line of the trunk, along one of the legs to the heel, care being taken that the tape is not stretched, so that it allows for the curves of the soft tissues. The length of the normal full-term infant is extremely constant, and is in marked contrast, in this respect, with the weight.

The Head, Trunk, and Extremities.—At birth the head and trunk are relatively long when compared with the extremities; while after birth the growth of the extremities proceeds at a much greater rate than that of the trunk as regards length. During this period, however, the breadth and capacity of the trunk undergo great increase. In the earliest weeks of life, the development of the circumference of the head and thorax is especially rapid. At birth the circumference of the head is about 13½ inches, and that of the thorax about 13 inches. The following table shows the approximate development:

The Average Growth of Head and Thorax during the First Two Years.

Age.	Circumference of Head.		Circumference of Thorax.
At birth - -	13½ inches	-	13 inches.
„ six weeks -	16 „	-	15 „
„ six months -	17 „	-	16½ „
„ nine months -	18½ „	-	17½ „
„ one year -	19 „	-	19½ „
„ two years -	20 „	-	21 „

Facial Development.—At birth, the base of the skull, the lower jaw and the whole of the facial region are extremely poorly developed. This disproportion between the face and the cranium is a distinctive characteristic of infancy. While in the adult the proportion of the face to the cranium is approximately as 1 to 2, in the full-term infant at birth it is as 1 to 8. The nasal bones are very poorly developed, so that frequently, at their junction with the frontal bone, the bridge of the nose is quite absent. The development of the nasal bone proceeds rapidly after birth for the first nine months; after this period the process is much slower, and it is not till about the seventh year of life that the nasal bones and nasopharynx attain a development approximating to that of the adult.

The Fontanelles. — The fontanelles are of especial importance in regard to the estimation of the general condition of the infant. The anterior fontanelle undergoes little or no diminution during the first nine months; at about this period it begins to diminish in size, and should be obliterated by the end of the eighteenth month of life. As a rule, the patency of the anterior fontanelle after the twentieth month must be regarded as pathological. After the first twelve months the size of the fontanelle needs also to be considered; at this time the diameter should not exceed 1 inch, and should be proportionally diminished as the infant approaches the age of eighteen months.

When the fontanelle is distinctly more extensive than is normal for the age, this should be regarded with suspicion. Of the causes leading to delay in ossification of the sutures, rachitis is by far the most common. While delay in ossification of the cranial sutures usually affords strong evidence of pathological changes, the presence of rachitis should never be excluded on the ground that ossification in this situation does not present any defect. In some cases rachitis may be well marked, while the anterior fontanelle is either closed or does not exhibit any departure from the normal standard. The posterior fontanelle is of very little practical importance; it is very small at birth, and in a week or two its outlines can only be definitely distinguished on careful palpation. It is almost invariably completely closed before the end of the eighth week. In premature infants this fontanelle is much more distinct, and its complete closure may be delayed for several months.

Muscular and Nervous Development.—In regard to the general nervous and muscular development, certain facts are of importance. About the end of the twelfth week, or between this and the sixteenth week, the infant will stretch out its hands and grasp objects placed within its reach. Somewhat earlier than this, the head can be held erect when the body is supported. At about the age of seven months, the infant is generally able to sit up without any support. At first it will only maintain this position for a few minutes at a time, but soon develops the power of maintaining the attitude, without fatigue, for a considerable period.

At eight or nine months of age, the first attempts at crawling are usually noticed. Before the power of standing erect is usually at all developed, the infant has used its legs freely, in conjunction with its arms, so that its powers of locomotion are very great. The power of standing depends not only on muscular strength, but on

the development of the sense of equilibrium. Many of the infantile means of locomotion place quite as much strain upon the muscles of the lower extremities as standing or walking. The development of the function of maintaining equilibrium is one of education primarily concerned with the nervous system, and the age at which infants can stand or walk varies greatly. As a rule, the infant makes attempts to stand at about the age of one year. When this is satisfactorily accomplished, walking is soon undertaken, and by the fifteenth month the infant can walk for short distances without support. It is, however, some considerable time before the gait is steady and well balanced.

The Special Senses.—The development of the special senses in the young is extremely interesting, but the most prominent features can only be briefly noted here. In the newly-born infant, vision, as understood in the adult, is almost completely absent. A bright light produces a painful stimulus, and the eyelids immediately close. At about the end of the first week of life, a light at some distance may induce the infant to turn its eyes in that direction, but to all other visual impressions it makes either a very feeble response or none at all.

Co-ordination of the muscles of the eye, for the purpose of bringing in focus a near or distant object, is almost entirely absent for some weeks, and only gradually develops. When this function is developing, the infant is seen to momentarily fix its eyes upon an object, but is unable to maintain the necessary co-ordination for any length of time. Recognition of objects is a complex process necessarily associated with mental development.

It is not definitely established till about the sixth month of life. The various phases of the development of vision and visual recognition are best illustrated in the wards of an infants' hospital. The contrast between the infant one month old and the infant of six months is extremely

marked, while the degrees of development are illustrated by the infants of intervening ages.

The auditory function in the newly-born infant does not exist. The author is not aware of a single case where, in the first twelve hours after birth, an infant has shown any evidence of hearing. The following is a curious instance demonstrating the absolute deafness of the newly-born infant. A glass tray full of instruments and carbolic lotion slipped on to a cement floor from the hands of the nurse carrying it. The loud crash for the moment alarmed everyone in the room. The infant, six hours old, within two feet of the fallen tray, slept on quite undisturbed.

For some days the function of hearing remains very defective, while at the end of seven days it is usually fully established. It is then found to be extremely acute, so that the infant is easily awakened by any noise and is often upset by loud noises as if they caused it pain.

The tactile and general nervous sensibility is very poorly developed in the young infant as compared with the child. External sensory stimuli are very imperfectly located, and the precise situation of acute pain, caused, for instance by a pin-prick, is but slowly recognized. For the same reason, the suffering from pain is seldom as acutely realized as in the older child.

The functions associated with sucking and with taste are extremely well developed. An infant will frequently refuse to take its food if it is not sufficiently sweetened or is not sufficiently warm. In regard to the taste of its food, the infant depends on its previous education. If it has been fed, for instance, on boiled milk throughout, it will not, as a rule, refuse this; but if it has been fed on unboiled milk, and is then supplied with milk that has been boiled, it will probably refuse it.

At the Infants Hospital, some difficulty is at first often met with in feeding the infants who have been brought

up on the artificial foods. As many of these foods contain a great excess of sugar, the infants, accustomed to the sweet taste, reject the milk mixtures containing the normal amount of lactose. It is sometimes necessary, in consequence, to yield to this factor, for the time, by giving a small amount of cane-sugar. As a rule, however, the infants are allowed to refuse until hunger compels them to yield, unless this is dangerous.

The acuteness of the taste is also illustrated by the infant's recognition of any serious alteration in its food mixture. An infant fed on a divided protein mixture will sometimes show distaste for a mixture in which the proteins have not been divided. As the taste is largely due to olfactory impressions, the function of smell must be developed; but in regard to the development of this sense, irrespective of taste, there is little evidence.

The sense of taste in the infant is remarkably acute. In the dietetic adjustments required for extremely delicate infants, the author makes use of very great refinements, increasing or decreasing the caseinogen, for example, by such amounts as 0·1 per cent. It is well known at the Infants Hospital that such changes as this are, not infrequently, instantly recognized by the infant, so much so that, on receiving the first feed of the new mixture, it will vigorously object, pushing the bottle away and ejecting the milk from its mouth.

Speech.—The infant begins to speak at about the end of the first year of life—that is, at about the same time that it begins to walk. Long before this, however, it has gained the power of expressing itself by sounds indicative of pleasure and annoyance. A happy and contented infant at about the sixth or seventh month of age will spend a large part of the day playing with toys and crowing to itself, much as a cat purrs. The close correspondence between these vocal expressions and those of speech may be best realized by watching a child of three

years and an infant of six months playing together. The speech of the child is replied to by a variety of vocal sounds on the part of the infant, and the alterations of the child's words and intonations find their counterpart in the varying sounds and inflections of the infant's voice.

When about one year old, the infant indicates the names of persons with whom it has been most intimately associated. From about the eighteenth month, it begins to connect words together so as to form phrases. When it has reached this stage the progress is extremely rapid.

The evolution of the function of speech is extremely instructive, not only in regard to the development of the infant itself, but also in relation to the essential features of language. If this development be traced from the beginning, it will be found that the first words spoken are the names of persons; then come the names of objects and of domestic animals. A comparatively rich vocabulary is then formed, consisting mainly of the names of persons, objects, etc. The nurse has usually only to indicate the person or the object to elicit the name. But no attempt is made to connect words with words.

The first sentences or phrases consist merely of words juxtaposed. Then these are combined with the verbs representing the simplest acts, and very gradually sentences of more and more elaborate construction are used. The words modifying names and acts are next introduced into the vocabulary; conjunctions and prepositions are added soon after; while the definite and indefinite articles are not used, as a rule, until infancy is passed. The personal pronouns are the last to appear, and are not used until the child has learnt to speak clearly and connectedly.

If, in normal circumstances, no attempt at speech has been made by an infant at eighteen months of age, some physical or mental defect is probably present, and if the

inability is still present at two years of age, the existence of some defect of this character is almost certain. As a rule, the female infant, by reason of her greater intuition, learns to speak earlier than the male. In infants deficient in length at birth, the development is almost invariably slower than that of the normal infant.

Dentition.—At birth the deciduous teeth are all formed, but they are situated beneath the submucous tissues of the gums. They grow, chiefly, by the deposition of osseous material at the roots, so that the teeth are gradually forced through the tissues. This dental development which has begun long before birth continues steadily afterwards, but the time at which the teeth emerge from the gums is subject to considerable variation, even in healthy infants. The time and order of their appearance are approximately as follows:

Approximate Date of Appearance of the Deciduous Teeth.

I.	6 to 7 months	-	2 lower central incisors.
II.	7 to 9 „	-	4 upper incisors.
III.	9 to 12 „	-	2 lower lateral incisors.
IV.	12 to 15 „	-	4 anterior molars.
V.	15 to 18 „	-	4 canines.
VI.	18 to 30 „	-	4 posterior molars.

An infant should have eight teeth at one year of age, sixteen teeth at eighteen months, and twenty teeth at between two and two and a half years. In the normal infant the eruption of teeth should always begin before it is seven months of age. If this does not occur, either congenital defect or imperfect nutrition is generally present.

The teeth, however, are by no means regular in the time and order of their appearance. In some cases teeth may appear as early as the fourth month; indeed, it is not very uncommon to find infants born with them. When at Queen Charlotte's Hospital, the author saw numerous instances of this.

General Examination.—When disorder is present, it is necessary, in order to ensure accuracy and completeness of diagnosis, that the character of the development should be accurately estimated, and in the preliminary investigation due attention should be given to the chief factors above referred to.

In determining the nature of the disorder, the *history* of the case should be carefully investigated. The facts in regard to the condition of the infant at birth, the character of the labour, the absence or presence of pressure symptoms soon after labour, need to be formulated as definitely as possible. The character of the diet must be thoroughly inquired into, as well as any digestive or other disorders associated with it. The weight record when available, and any fall in weight that has been noticed, must receive attention. At a later stage of the infant's life, the general rate of development should be ascertained by reference to the weight, the time the teeth appeared, the period at which the infant was able to sit up by itself, to stand, to walk, and to speak.

Coming to the present illness, all facts connected with its incidence need to be precisely defined. Here much difficulty may be encountered, and especial care is needed to avoid placing too definite an interpretation upon statements which are frequently not intended to bear the meaning the words actually involve.

Accuracy of statement is frequently obliterated by the desire of the mother or nurse to impress the hearer with some phase of the disorder which is considered by them to be the essential element, but which is often a comparatively unimportant incident of the disorder. In consequence, there is a great tendency to lay undue emphasis upon certain facts, to the exclusion of others possibly much more important.

General Appearance.—The general appearance of the infant sometimes affords valuable indications. The char-

acter of the skin and complexion are often suggestive. The skin may be very dry or excessively moist, the face may be pallid, cachectic, or cyanosed. The cheeks and feet should be felt to determine whether they possess their normal warmth.

The facial expression is often a valuable indication. Instead of the calm and bright expression of health, the upper lip may be retracted, indicating abdominal pain; or the eyebrows may be furrowed, indicating a more localized pain.

The Cry of the Infant.—The cry of the infant is not without its diagnostic value. It is the infant's chief means of expression, and the response varies with the stimulus.

The cry of discontent is perhaps the one most commonly heard. It is especially characteristic during the first few months of life, and must be distinguished from that associated with pain and illness. It may be largely contributed to by the mother or nurse constantly taking the infant from its cot, performing various gymnastic exercises with the infant, and talking to it in the well-known nursery jargon. Each nursery seems to have its own special traditions in the variety of amusements provided for the infant.

The result of these procedures is that the infant refuses to be contented in its cot until it is tired out. At most other times, when left in the cot, it immediately demands a renewal of attention. While the infant is crying from this cause, it is often difficult to determine its origin. It is, however, easily diagnosed by watching the infant when it has obtained what it wants. If the cry then ceases and the infant is happy, the nature of the plaint is clear.

In these cases, it is necessary to caution the nurse and all concerned with the care of the infant against the practice of constantly carrying and exciting the infant. It is extremely bad for the infant's nervous system, results

in the infant getting far less sleep than it requires, and accounts for many of the more trivial digestive disturbances. The greater part of the young infant's life should be spent in sleeping and feeding, and the habit of crying because it is placed in the cot must be thoroughly broken. When it has been determined that the cry is of this character, the infant should be allowed to cry till it is tired, but not be taken from its bed. In a very short period it will learn the futility of its lament and go to sleep.

The peevish, fretful cry of hunger is generally recognizable. It is not constant, and often ceases altogether for a short time when the infant is provided with something to suck. Frequently it sucks its thumb or fist. The cry ceases as soon as the infant is provided with the food it needs in sufficient amount.

The cry of acute pain is characteristic—it is sharp and piercing, and is associated with contraction of the limbs and features. It is easy to see that something is hurting the baby severely; it may be internal, such as colic, or external, arising from injury from a safety-pin or other cause.

One of the most frequently misinterpreted cries is that of pain from indigestion. The cry itself is not so sharp as that of acute pain, and closely resembles that of hunger. Moreover, it frequently ceases for a few minutes after food. The food is given at about 100° F., and thus a little more warm food acts for the time as a fomentation. As soon as this action has ceased, the pain becomes increased and the crying is renewed. Discrimination must therefore be exercised, and an investigation of the case will determine the meaning of the plaint.

In some cases, acute gastric and intestinal indigestion is associated with a ravenous appetite. These are the cases of infants fed on food large in bulk, but containing starch, and, in other respects, altogether inadequate for nutrition.

Physical Examination. — In the examination of the infant some practical points are of importance. The temperature should be taken by the thermometer placed in the rectum. No other method can be relied upon. In the case of young infants, a raised temperature, in the absence of other signs, means very little. Moreover, the normal temperature of the infant may be as high as 99·5° F.; or, at any rate, this temperature may be found in the absence of any signs of disorder. A subnormal temperature in an infant is much more serious than the rise of a degree or two.

As soon as the preliminary observations have been made, the infant should be completely stripped, and the whole body should be rapidly but systematically examined. This being completed, the infant should then be wrapped in a blanket, only those parts being exposed which require further examination. The preliminary examination of the naked infant should never be omitted, else some factor of the utmost importance may be altogether missed. It need hardly be said that precautions must be taken to prevent chill from exposure.

The head should be gently palpated, to determine the degree of ossification of the sutures and the condition of the anterior fontanelle. Tenderness of the limbs, especially of the legs, so that the infant cries on moderate pressure being applied to them, is a significant sign; while the general inspection of the limbs, chest, and abdomen, will enable the observer to determine, to some extent, the degree of nutrition or wasting, and to detect the presence of any of the characteristic signs of atrophy, scorbutus, or rachitis.

The heart and lungs may then be examined, though, in regard to nutritional disorders, these organs are only indirectly affected. The presence or absence of concurrent diseases—such, for instance, as congenital heart disease—must be determined. The abdomen requires careful

attention. The presence or absence of flatulence, distension, ascites, general or localized tenderness, should be noted, and the position and size of the liver and spleen need to be accurately determined. The mouth and throat should be inspected at quite the end of the examination, as the infant usually resents this more than anything else, and this should therefore be postponed till the other points have been decided.

CHAPTER XIII

GASTRIC AND INTESTINAL DISORDER

The methods of feeding and managing young infants commonly practised are so widely divorced from everything that is efficient and appropriate that digestive disorder is the rule rather than the exception, and the infant who is not ill in the first year of its life is regarded rather as a phenomenon.

It would almost appear to be the fact that vomiting, colic, flatulence, constipation and diarrhœa have come to be regarded, not only by the natural guardians of infants, but even by some medical men, as the inevitable incidents, if not the natural functions, of infancy, and the unfortunate baby toils through its painful experiences on a diet of boiled milk and the British Pharmacopœia. Seventy-five per cent. of the cases of nutritional disease and disorder owe their origin to the lack of rational management of the infant in regard to its hygiene and diet. Grave as the final consequences are, they have resulted from ailments which, comparatively slight at their outset, have been allowed to continue and develop uncorrected.

Indigestion.—In the early months of life comparatively slight alterations, either in the quality or quantity of the food, may produce marked disturbance and suffering, so as to altogether interfere with the comfort and sleep of the infant. In this respect it need hardly be said that infants

vary very much. An infant may be vigorous, healthy, and yet 'delicate.' Another infant, apparently not so vigorous nor so healthy in appearance, may show a much greater tolerance in regard to the digestion of its food.

The signs of indigestion in the infant are somewhat as follows. Soon after taking its meal, the infant shows signs of discomfort which are at first slight and gradually increase. It is restless, brings up gas from the stomach at intervals, cries almost incessantly, occasionally screaming violently, and draws up its legs as more severe spasms of pain occur. There is often a good deal of more or less persistent hiccough, with occasional eructations of sour food. In some cases actual vomiting occurs, with the ejection of large curdled masses.

In other cases the infant is more apathetic, cries scarcely at all, but looks ill. The face and lips twitch, the mouth is blue, and respiration is laboured. These signs are more frequently found in cases where atony and dilatation of the stomach have developed, so that the food lies as an inert mass in the stomach. As a rule, the infant is relieved by the expulsion of a large quantity of gas or by vomiting.

The intestines act irregularly: sometimes the dejections are nearly normal, though never typically so; at other times they are green in colour, acrid and offensive, and all gradations between the normal and the seriously abnormal are met with.

The infant suffering after every meal, unable to sleep quietly, soiling its clothes with regurgitated food, smelling sour, constantly fretful and crying, is a common clinical experience. Many more serious symptoms develop if the disorder is allowed to continue, but for a time the condition is apt to remain *in statu quo*.

The infant loses or does not gain in weight, or gains but slowly and irregularly. The ignorant nurse is content with calling it a 'sick baby,' and the anxious

mother complains that the baby 'never seems really well.' In a great many cases all sorts of expedients have been resorted to, and nearly always the unfortunate infant has been dosed with drugs in which 'grey powder' or some such preparation largely figures. Little or no improvement has taken place, and those chiefly concerned have perhaps resigned themselves to the condition as one which apparently cannot be avoided. Yet there is no class of case which more quickly or more satisfactorily responds to really adequate management and treatment.

Overfeeding is one of the commonest causes of indigestion. The vigorous and hungry infant at the breast may, in a few minutes, swallow a much greater quantity of milk than can be dealt with by the stomach in the time.

Such instances are found where the mother has a large quantity of milk which flows more readily than usual, so that the infant is not restrained by the normal effort necessary to obtain its food. The infant is disturbed and restless after its meal, the food is regurgitated in considerable amount soon after nursing, and frequently it is continuously uncomfortable until a considerable quantity is suddenly vomited. One of the first necessary inquiries in regard to the breast-fed infant is as to the duration of its feeding. From fifteen to twenty minutes should be the time given to feeding on each occasion, and where the milk flows too freely, precautions must be taken to prevent the infant's stomach being overtaxed by the sudden ingestion of too large a quantity. It is also advisable to allow several intermissions in the feeding, so that the stomach may accommodate itself to the incoming milk and is not called upon to deal with too great bulk at any one time.

When the infant has once got into the habit of distending its stomach at each meal, the control of the nursing requires much care and perseverance. As soon as the

infant begins to show signs that its hunger is appeased and is no longer vigorous in sucking, as at the outset, the feeding should be stopped. The fact that it cries on being taken from the breast, as if not satisfied, must not be allowed to interfere with this procedure, since it is necessary to break the habit of overfeeding, and, until this is broken, the disorder will not cease.

If this constant distension is allowed to continue, atony of the stomach ensues with dilatation. In consequence, a large amount of milk lies in the stomach undergoing abnormal fermentative changes, and digestion becomes seriously perverted from the normal.

The secretory activity of the gastric cells and the peristalsis of the muscular wall are both enfeebled, so that a large amount of decomposing milk and its products are present, and the stomach is never empty. The infant is sorely troubled with constant flatulence and regurgitation of sour milk; definite vomiting may occur, but, as a rule, in this class of case it is not a prominent symptom, owing to the atony of the stomach.

The above conditions appear even more commonly in bottle-fed infants, and are frequently due to the same cause. The treatment lies in the regulation of the amount of food taken and in the systematic control of the feeding.

In the case of breast feeding, the passage of the milk should be regulated by the mother compressing the nipple between her fingers, so that the infant is only able to obtain a gradual supply. This method has another advantage: the process of sucking demands considerable effort on the part of the infant, and the degree of fatigue is probably one of the factors inducing the infant to relinquish vigorous sucking.

In bottle feeding, the same principle must be observed. The rubber teat must be provided with an outlet small and resistant, in order that effort is required on the part of the infant to obtain its food, so that the amount

obtained is not more than it should receive. The bottle used at the Infants Hospital is of the nature of a tube rather than a bottle. It has no valve, but is simply a glass tube with a small opening at one end. For feeding the infant the tube is elevated, and care is taken to secure that the neck is always full of milk, so that there is no air-space between the milk and the tube. When the infant sucks it creates a partial vacuum; it removes some of the milk, and air cannot replace the milk while it is sucking. The result is that it becomes increasingly difficult for the infant to obtain the milk, and a vigorous infant will continue sucking till he is compelled to release the teat, because he cannot get the milk. The teat then collapses and partially shrinks into the bottle; the air passes into the milk and destroys the vacuum; the teat is relieved from the suction pressure, and the infant can proceed.

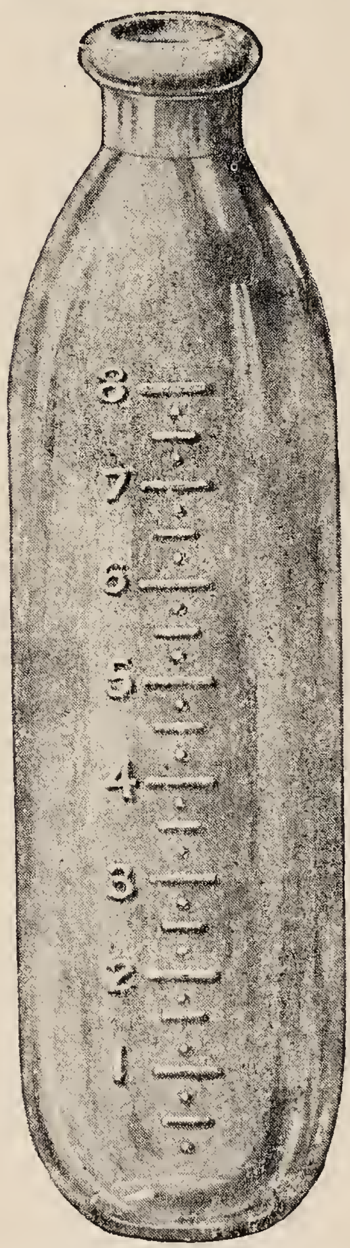

Fig 45.—Infant's Feeding Bottle.

Gastric Dilatation.—Where definite dilatation of the stomach has occured as the result of the continuous neglect of these precautions, it is necessary to resort to thorough measures. Food must only be given in small quantities, and the deficiency of each feed must be compensated for by increased frequency of feeding. When dilatation of the stomach has persisted for some time, treatment is tedious and difficult, and a large number of cases are seen where the affection has become chronic.

The infant is pallid, smells sour, and is clearly very much out of health. It gains weight slowly or not at all,

and the digestion is perverse. The mother or nurse has resorted to the most dilute mixtures, such as condensed milk diluted some fifteen times, since foods richer than this have proved to be too much for the infant's digestion. Great perseverance and systematic attention are required to bring these infants back to a normal condition, and the greatest refinements of substitute feeding may be necessary.

At any time, the chronic disorder may develop into acute intestinal toxæmia as a result of putrefaction of the food. When this occurs, the prognosis is grave. The chronic ill-health of the infant has very gravely impaired its power of resistance, and a fatal result may rapidly ensue.

Other errors, either in the quality or quantity of the diet, may be responsible for disturbance of some part of the digestive apparatus, and these, at first, may not be associated with any great degree of general disorder.

Stomatitis.—Neglect of proper precautions is frequently followed by inflammation of the mucous membrane of the mouth. This may be of a catarrhal or ulcerative character, but by far the most common form is parasitic stomatitis (thrush), due to the fungus *Saccharomyces albicans.* This organism is widely distributed, but it does not develop upon healthy mucous membrane. Slight abrasions or a catarrhal condition of the mucous membrane are sufficient to permit of its development.

The appearance of thrush is characteristic. Small white flakes resembling fragments of curdled milk are distributed over the buccal mucous membrane, chiefly on the tongue and on the cheeks in line with the gums. Around these white spots are areolæ of inflamed mucous membrane, and when the flakes are forcibly removed there is generally a little bleeding from the denuded mucous membrane. If uninterfered with, the growth may extend so as to completely cover the mouth and pharynx. The

mouth is dry, the tongue is furred, and the infant is generally suffering from gastro-intestinal indigestion.

If any doubt exists as to the nature of the condition, a fragment of the white masses should be placed on a slide and be moistened with a minim of liquor potassæ. In the case of thrush, on microscopical examination the fine threads (the mycelium) and small oval bodies (the spores), characteristic of the growth, will be readily detected.

The disease is always to be prevented by the systematic cleansing of the mouth after feeding, and by attention to the adequate cleansing of the nipples and everything coming in contact with the infant's mouth. A solution of boracic acid is the most useful for this purpose, but care should be taken to see that all traces of this are removed from the nipple before suckling.

When the disease is present, the growths should be gently but thoroughly removed by a small swab of cotton-wool soaked in glycerinum boracis, and any further developments of the growth should be dealt with in the same way as soon as they appear.

Catarrhal stomatitis occurs occasionally in infants, and when severe is a distressing complication, making all attempts at feeding painful and difficult. In a well-marked case the vessels are dilated; the mucous membrane is very red and bleeds readily; the gums are much swollen and the mouth is hot. Saliva is freely poured out and is frequently present in extraordinary amount, so that it issues from the mouth in an almost continuous stream. The lips, chin, and cheeks may be much irritated, and, in consequence, become eczematous. The infant refuses food on account of the pain, and rapidly loses ground unless the condition is quickly dealt with.

In order to check the inflammation as soon as possible, the whole mouth should be swabbed with a pledget of cotton-wool which has been immersed in a 2 per cent.

solution of silver nitrate, and from which all excess of the solution has been removed by pressure. The mouth should then be again swabbed with a solution of boracic acid. The skin in the neighbourhood of the mouth is best treated by being smeared with vaseline or oxide of zinc ointment, to prevent irritation from the saliva. Feeding should be carried out by means of a spoon, to save the infant the pain of sucking. If food is absolutely refused, the infant must be fed by means of the nasal tube. On no account must the infant be allowed to be without its food by reason of the pain involved in feeding.

These severe cases are comparatively infrequent in the case of the young infant, and only occur when it has been seriously neglected. Much milder forms are somewhat frequent, and they respond readily to suitable treatment.

The first dentition is an occasion when catarrhal stomatitis may appear; but the infant is older, the disorder is much less severe, and the general condition of the infant in these circumstances is very rarely at all serious.

Frequently associated with digestive disturbance is the rash popularly known as the 'gum rash.' *Lichen urticatus* is usually seen as raised hard papules with a somewhat translucent centre. The rash often gives rise to great irritation which calls for sedative applications, of which one of the best is liquor carbonis detergens in the proportion of one part to four parts of water. The rash is seen in many guises in different infants, but it should always be regarded as evidence that some dietetic error is present. It is of extremely frequent occurrence when cane-sugar or maltose is present. The severest forms are seen when the infant has been fed on an artificial food containing a large amount of maltose.

In the case of both the breast-fed and the substitute-fed infant some defect either in the character of the food

or the method of its supply is the commonest cause of digestive disturbance, but this is by no means always the case.

The indefinite term 'chill' has a very definite application in the case of young infants. The relatively great body-surface necessarily leads to a comparatively excessive loss of heat. When this loss of heat is not counterbalanced by an equal creation of heat, the lower extremities, being farthest from the heart, are the first to suffer. Here the blood becomes cooled; the venous blood, thus cooled, returning through the vena cava, causes the temperature of the abdominal viscera to become subnormal.

Vomiting.—Vomiting may arise, indicating some defect in the breast milk or the imperfect adjustment of the substitute food. In the case of bottle-fed infants, this frequently leads to the rejection by the mother or nurse of an improperly modified cow's milk in favour of a preparation which the infant can digest, but which is gravely deficient in nutritive properties. The statement that the infant 'cannot take cow's milk' is the almost constant explanation of the fact that the infant is being fed on a condensed milk or other artificial food. If the individual factors of these cases are properly appreciated, there is usually very little difficulty in providing a modified milk adequately meeting the indications.

It should, however, be recollected that vomiting is by no means always due to dietetic error, or even to dietetic excess. There are certain cases in older infants where too dilute a food will produce vomiting. This was notably the case with an infant in the hospital who was continually vomiting on a weak mixture containing a very small proportion of both fat and proteins. The fat was increased to 3 per cent., and the proteins to 1·25 per cent., and the vomiting immediately ceased. The infant presented many signs of nervous malnutrition, and the cause of the vomit-

ing was an excessive secretion of acid. By means of fat to inhibit the excess and of protein to combine with the normal secretion the irritant was removed and the vomiting ceased.

Infants suffering from congenital syphilis are generally highly nervous and nervous vomiting closely allied in its immediate causation to that just described is frequently seen. In these and other cases where the nervous system is unstable, vomiting at irregular intervals is not uncommon ; for hypersecretion of hydrochloric acid is extremely liable to occur when the nervous equilibrium is disturbed. The characteristic of this vomiting is that the vomit generally consists of clear watery fluid, while its incidence shows that it has, as a rule, but little relation to the precise diet. In these cases the general condition must be treated, and the nervous system must be assisted by protecting the infant from excitement and unrest. Bromide of potassium is often useful.

Gastric Indigestion.—Where there has been persistent gastric disorder with continued vomiting of curdled material, the preliminary treatment should consist of lavage of the stomach followed by an efficient dose of castor-oil to expel the intestinal contents.

Stomach-Washing.—Various practical details in regard to washing out the stomach need some consideration. The apparatus required consists of a soft rubber catheter, in size from No. 8 to No. 10 (provided with a large eye), a glass funnel holding about 5 ounces, two rubber tubes connected by glass tubing, a jug holding about a quart, and a basin in which to empty the washings.

Either a towel or a rubber sheet may be used to protect the infant from wetting. Plain boiled water may be used, but the addition of sodium bicarbonate (1 drachm to the pint) is useful, as this dissolves to some extent the mucus and allays irritation of the gastric mucous membrane.

The temperature of the solution should be about 103° F., and not higher than 106° F.

The attempt to pass the tube when the infant is capable of struggling and wriggling into every conceivable position is not likely to be successful. The infant should be held in a sitting posture on the nurse's lap, and the operator should be seated immediately in front. All the nurse can do in the case of a vigorous infant is to restrain its body and limbs. The restraint of the head must be undertaken by someone standing behind the nurse, holding the head with one hand on each side. There must also be another assistant to pour the solution into the funnel as required.

In passing the tube, care must be taken that only the proper length is passed, else it will coil itself in the stomach; 10 inches from the gums is usually a sufficient length. The funnel should be raised as high as possible immediately the tube is passed, in order to allow of the escape of gas. It should then be lowered to the greatest extent possible to permit the exit of the stomach contents. This does not always occur, but it is greatly facilitated by a simple manœuvre. While the tube is held firmly at the mouth, without obliterating its calibre, by one hand, the external portion of the tube should be compressed by the finger and thumb of the other hand, sweeping towards the funnel.

From about 1 to 5 ounces of the fluid (according to the age of the infant) should then be gently poured into the funnel, and this is slowly raised till a free flow into the stomach takes place. As soon as the fluid has passed into the stomach, the funnel should be lowered and the washings siphoned into the basin. This procedure is repeated until the fluid returns quite clear.

At first, the washings are loaded with mucus and small curds. The large curds in the stomach are disintegrated by the repeated washings, so that the stomach is com-

pletely cleared of the fermenting mass. It is usually advisable to leave about 1 ounce of the solution in the stomach. The infant should then be put to bed and kept warm. As a rule, slight collapse follows the operation, but it is seldom severe and is speedily checked by a little brandy.

Food should be postponed for as long as possible in order to give the stomach rest. The first thing to be given is castor-oil, and after its administration a further period of at least two hours should be allowed to elapse.

Valuable as is gastric lavage in treating the initial conditions, it should not require to be resorted to at all frequently. The indigestion should be treated by precise adjustment of the diet. At the Infants Hospital gastric lavage is very rarely resorted to, for the signs indicating it—chronic fermentation of the gastric contents with chronic vomiting—are very seldom seen. The elimination of the excess of caseinogen or of any other disturbing element is the direct method of controlling these disorders.

In the case of the breast-fed infant, the mother's milk must not be allowed unless it is clear that this is not responsible for the illness. In the other cases temporary substitute feeding should be undertaken. The milk mixture provided should be of a delicate character, and rather more alkaline than usual. For an infant eight weeks old the following prescription is likely to prove suitable:

		Per Cent.
℞	Fat - - - - -	2·00
	Lactose - - - -	6·00
	Whey proteins - -	0·50
	Caseinogen - - -	0·15
	Alkalinity - - -	10·00

Unheated. Nine feedings, each containing 2½ ounces.

When the mixture agrees with the infant, the constituents should be gradually increased in amount,

especial care, however, being exercised in regard to the caseinogen.

Congenital Pyloric Stenosis. — Congenital pyloric stenosis is an affection which has received much attention in recent years. In the author's experience, there is always present in the genuine case a slight degree of congenital defect, for in the cases seen by him the length has always been less than 21 inches. Two cases recently under his care illustrate this, for one infant was $20\frac{1}{4}$ inches in length, the other was $19\frac{3}{4}$ inches. The symptoms almost invariably appear in the first three months of life, and it is characteristic of the condition that it is never seen at birth, but develops some three or four weeks later. Breast-fed infants are quite as liable to suffer from it as others not so fed.

Vomiting is the first sign, and gradually increases both in frequency and severity. The vomiting does not regularly occur after every feeding, but tends to be of the type belonging to gastric dilatation, the vomiting being sudden and violent, and the amount of fluid and curdled food being in some cases quite remarkable. Associated with the vomiting, as a rule, is marked constipation. The infant wastes and rapidly becomes ill and feeble, so that great anxiety is aroused by its condition.

In a typical case the physical signs in the abdomen are quite characteristic. The peristalsis of the stomach is clearly seen. There is obvious gastric dilatation, while in the neighbourhood of the pylorus may be felt a hard rounded body—the contracted pylorus. In reference to treatment and prognosis, certain points need to be borne in mind. When the affection occurs in puny infants not fully developed and under $19\frac{1}{2}$ inches in length, the prognosis is bad, and the best treatment—medical or surgical—is likely to be of little avail.

When the infant is of fair weight and not less than 20 inches in length, the prognosis is favourable if the

infant receive the expert care and attention which is essential. The essence of treatment is to ensure that the infant receives a nourishing food, which leaves no indigestible residue in the stomach. Small doses of opium (Tr. Camph. Co., ♏i. or ♏ii.) and bromide of potassium are valuable in allaying the general nervous disturbance which is frequently well marked and in relieving the spasm of the pylorus. The infant should be fed frequently and with small amounts. Caseinogen should be entirely eliminated; fat may be given in moderate amount, and lactose may be given freely—6 or 7 per cent. The constipation must not be allowed to continue, for the normal action of the intestines will do much to establish the equilibrium of the nervous mechanism of digestion. In regard to surgical treatment, the author finds little to recommend it. If the congenital defect is slight, efficient medical treatment is, as a rule, attended with excellent results. If the defect is greater, so that medical treatment is likely to fail, surgical treatment fails for the same reason.

The affection is one which must be broadly considered. It is a spasmodic condition occurring in an infant in whom the nervous mechanism of digestion is unstable. The striking features of the affection are not seen till gastric dilatation has occurred, and it is this which accounts for the fact that 'congenital' pyloric stenosis is not seen at birth, but some weeks later. With the occurrence of this condition the functional defect is much magnified. The dilated stomach not only gives rise to spasmodic contractions, by dragging upon the pylorus, but, in consequence of the greater part of the gastric contents being at a lower level than the pyloric opening, the passage of the contents through the pylorus is greatly hindered. The treatment of the gastric dilatation is therefore of primary importance, and it will be greatly assisted by medicines acting on the nervous system, so that the

irritability of the pylorus is diminished. The following case affords a typical illustration of pyloric stenosis. The age of the infant, the weight, and the shortness in length, are quite characteristic.

R. H. (R. 606)[1] when first seen was eleven weeks old, weighed 7 pounds 10 ounces, and was 19½ inches in length.

It was not breast-fed at all. At first a mixture of milk and water was given. Constant vomiting of dense curd occurred. Milk with barley-water was then given. A variety of foods were then tried—humanized milk, malted milk, etc. Marked constipation had been present throughout.

The case was sent to the author from Broadstairs by Drs. Moon and Brightman.

The physical signs left no room for doubt. The gastric peristalsis

Date.	Fat.	Lactose.	Whey Proteins.	Caseinogen.	Whole Proteins.	Feeds per Diem.	Amount in Ounces.
June 6	0·75	4·00	0·75	Nil	—	12	2
„ 7	1·00	4·00	0·75	Nil	—	12	2
„ 11	1·25	5·00	0·75	Nil	—	12	2½
„ 14	1·25	5·00	0·50	0·25	—	12	3
„ 18	1·50	5·50	0·50	0·25	—	10	3½
„ 25	1·50	5·50	0·50	0·40	—	10	3½
„ 28	1·50	5·50	0·50	0·50	—	10	4
July 5	1·50	5·50	0·50	0·75	—	10	4
„ 12	2·00	5·50	0·50	0·75	—	10	4
„ 19	2·25	5·50	0·50	1·00	—	10	5
„ 23	2·75	5·50	0·50	1·00	—	10	5
„ 26	2·75	6·00	—	—	1·25	8	6
„ 30	3·00	6·00	—	—	1·25	8	6

PYLORIC STENOSIS. DIET CHART.

was readily seen, while the dilatation of the stomach was so marked that at times it protruded from the epigastric region like a large egg. The pylorus in spasmodic contracture could easily be felt as a hard lump. The skin of the infant was extremely dry and harsh.

[1] The reference number in brackets in this and other cases cited refers to the register of The Infants Hospital.

The patient was transferred to the Infants Hospital. On the second day it was very collapsed It soon rallied, and from this time slowly progressed. Stomach-washing was not resorted to. The treatment was entirely dietetic, and the details are shown in the diet chart.

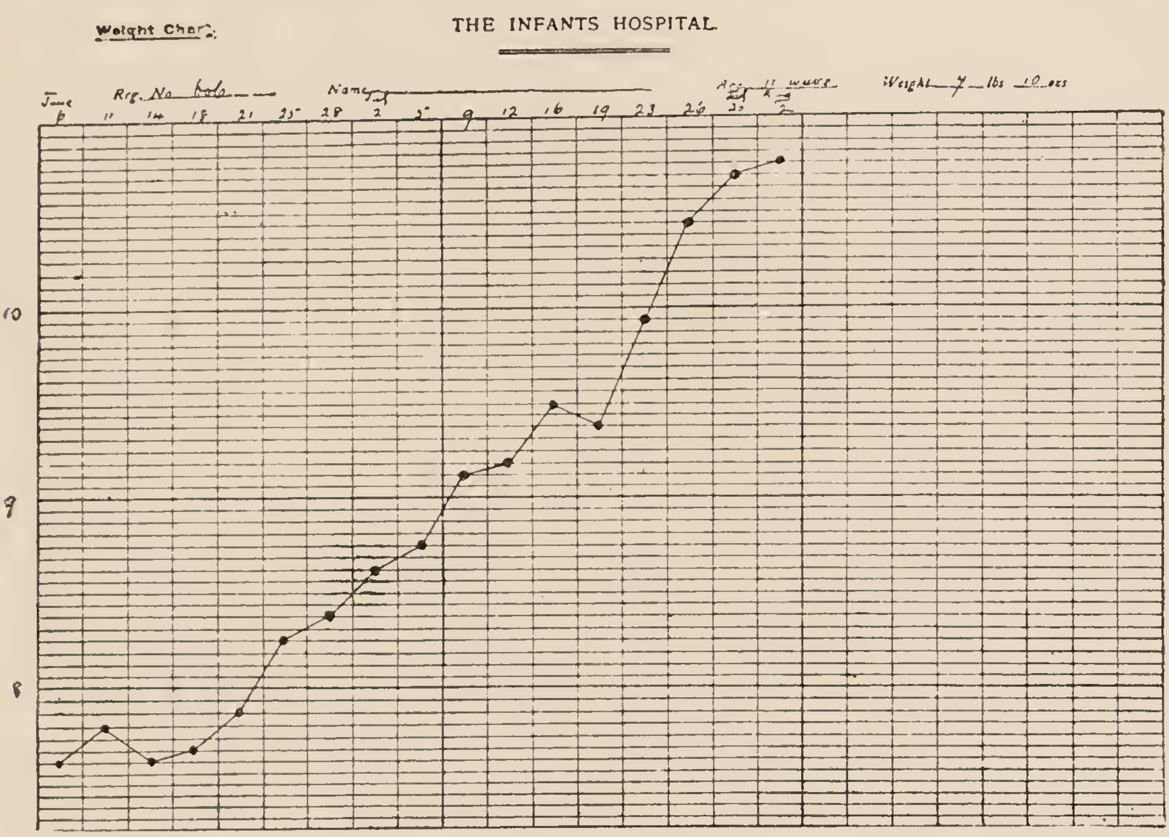

FIG 46.—PYLORIC STENOSIS. WEIGHT CHART.

The vomiting and constipation ceased within twenty-four hours, but marked progress was not made till the infant had been in the hospital about a fortnight. The skin had remained dry till this period; the infant then freely perspired, and from this time the progress was uninterrupted.

Intestinal Disorder — Constipation.—Constipation is a very common affection, and is always a pathological feature. The chemistry of the digestive processes needs to be exceptionally active in the young infant to meet the nutritional requirements, and the daily evacuation of two or three motions of a semi-liquid character represents the rate of intestinal action which is requisite. Where this falls below the normal many pathological features are introduced.

Overfeeding with food of improper or perverted

character is one of the commonest causes of constipation. The two analyses following represent—(1) the normal composition of the food of an infant of about three months of age; (2) the composition of the food that is commonly given to a bottle-fed infant at about this age. The latter analysis simply represents a mixture of equal parts of milk and water, with some added sugar.

I.	Per Cent.	II.	Per Cent.
Fat	3·50	Fat	1·75
Lactose	7·00	Lactose	2·25
Whey proteins	0·75	Cane-sugar	5·00
Caseinogen	0·50	Whey proteins	0·50
		Caseinogen	1·50

The normal healthy infant cannot digest such an amount of caseinogen as that shown in the second column. It is precipitated in dense tough curds and entangles with it the fat globules, so that the infant is gorged with a mass of food that continuously impedes the normal digestive processes. Even if the precipitation is prevented by peptonization or by sodium citrate or by other artificial procedures, the infant only escapes one form of dietetic ill to fall into another. Add to these defects the fact that in all probability the milk mixture is boiled or sterilized or pasteurized, and we have all the conditions necessary to produce chronic constipation. The treatment is obvious: it is to abandon the use of foods so ill adapted to the physiological needs of the infant, and place the infant on a fresh unboiled milk mixture corresponding with its requirements. But will the mixture of the composition indicated in the first column meet the needs of an infant that has suffered from persistent constipation for the previous two months? It is not probable. It would probably produce diarrhœa. That composition represents the food of an infant that has been well treated throughout, that has not suffered from intestinal disorder. The suffering infant cannot proceed

from disease to health in the course of an hour or two, and the practitioner will do well to make allowance for these clinical factors, and in doing so he will much reduce the fat and the lactose, until the infant has had time to react to the healthy stimulus of healthy food.

Enteritis and Ileo-Colitis.—Diarrhœa is an extremely common disorder in young infants, and in this chapter only the simpler types which belong to the class of digestive derangements will be dealt with, acute intestinal toxæmia being reserved for separate consideration. Every variety of the simple type is seen, and is caused in the vast majority of cases by errors of diet. The excessive amount of curd-forming material gives rise to continual irritation of the intestine, attended with much pain and colic; at other times the food mixtures contain large quantities of farinaceous material, which cause violent disturbance. As a result of the continual irritation an intestinal catarrh develops, and it is this feature of the chronic diarrhœa—sometimes alternating with constipation—which has to be continually borne in mind. At first the condition is one of simple irritation. Cease the administration of the evil food, clear the intestine with a suitable aperient, such as castor-oil, and the trouble is speedily ended. In these cases the cause is entirely in the contents of the alimentary canal. But when the irritative and fermentative diarrhœa is allowed to continue, the mucous membrane becomes affected and chronic catarrhal enteritis is established. This affection gravely threatens the health of the infant; the extent of the affected mucous membrane, the direct interference with nutrition resulting from the disordered condition of the intestinal glands, the mucous discharge thrown out, sometimes in large amount,—all exhaust and weaken the infant. The dejections at first usually contain masses of undigested food and are offensive, a characteristic which should always receive immediate attention;

for the normal dejection of the infant is practically odourless, and the offensive smell arises from putrefactive changes in undigested food. As the disorder progresses the dejections become frequent, contain masses of mucus, and are thin and watery in character and green in colour. The treatment of such a case when it has reached an advanced stage is one calling for the greatest attention to detail and, sometimes, much patience. For a mucous membrane so irritated and inflamed rest is the great essential, and the fact that absolute rest cannot be obtained, since the infant must be fed, only serves to emphasize the necessity for the most careful and precise dietetic adjustments. Medicinal treatment will be of great assistance, but it will be almost useless unless the dietetic necessities are adequately dealt with. If the condition is allowed to proceed to its final stage, three results may happen: (1) Chronic muco-enteritis, often of an incurable character, so that the infant dies from inanition and exhaustion after a prolonged illness; (2) the development of acute intestinal toxæmia; (3) atrophy.

Examination of the Intestinal Dejections.—Much valuable information may be gained by a careful examination of the dejections. The presence of an abnormal amount of fat in the dejections is an extremely important indication. Fat may be present as—(*a*) neutral fat, (*b*) fatty acids, (*c*) soaps. The pasty, greasy, constipated dejection with an alkaline reaction usually contains a large amount of fat in the form of soaps. This affords clear evidence that the processes of intestinal digestion are abnormal and unhealthy. Dejections which are liquid and light yellow in colour generally contain a considerable amount of fatty acids. As a rule, the symptoms in these cases are severe, the purging is extreme, and exhaustion rapidly supervenes. Three forms of curds may generally be recognized: (1) A dense tough curd, consisting for the most part of casein; (2) a rather large, soft, friable curd, which

is, as a rule, rather shiny, and consists for the most part of fat; (3) glistening pinhead granules (these consist almost entirely of fat).

In some cases large 'curds' may be found to consist of coagulated mucus. Fat-curds may closely resemble casein-curds. The ether test affords a simple method of differentiation. The curd is thoroughly broken up and treated with ether; the fat-curd dissolves, while the casein-curd is unaltered. While fat absorption is remarkably good in the healthy infant, this process is often gravely interfered with in conditions of intestinal disorder. Hence it frequently becomes necessary to determine the amount and character of the fats present in the dejections. Microscopical examination yields valuable information in regard to this. A thin film of the dejection is prepared, and is stained with a saturated alcoholic solution of Sudan III. Neutral fat drops stain red. Fatty acids may be in the form of drops or crystals; the drops are always stained, the crystals vary. Fat in the form of soaps does not stain. By adding a drop of glacial acetic acid to the previously stained preparation, and warming it gently until bubbling occurs, the soaps are decomposed, and drops of fatty acid are produced which stain red. With carbol fuchsin neutral fat is unstained; fatty acids stain a brilliant red and soaps a dull red.[1]

Certain general features in regard to the macroscopical appearance of the dejections may be mentioned. When the diet is high in proteins and low in fat, the colour of the dejection is usually brown in colour rather than yellow, the odour is more or less offensive, and the reaction is alkaline. If the carbohydrates are high in amount, the dejections still tend to be brown, but the reaction will be acid. If the acid reaction is excessive, the

[1] *Vide* 'Physiology and Pathology of the Digestion of Fat in Infancy,' by Fritz B. Talbot, M.D., *American Journal of Diseases of Children*, March, 1911.

buttocks will be excoriated. Dejections which cause excoriation of the buttocks are almost invariably acid.[1]

Treatment of Enteritis.—In all cases of intestinal catarrh the infant must be kept warm; the extremities especially must be kept thoroughly warm. An infant suffering from muco-enteritis, whose feet are cold, has but little chance of recovery. Too much stress cannot be laid on this point, for, as a result of the lowered vitality, it is not easy to keep the extremities warm. The most effective means is to insure the preservation of the internal heat by wrapping the feet and legs in cotton-wool, covering them with warm stockings. If this is not attended to, the most efficient medical and dietetic treatment will be greatly hindered. Castor-oil should then be administered, and extremely dilute food should be given for a few days. Very frequently any form of milk may be too much for the irritated intestine, and albumin-water with a little sugar may be given for twenty-four or forty-eight hours. When milk is given it must be of an easily assimilable form; the fat must be low in amount—1 per cent. is quite enough to begin with. The lactose must be much reduced from the normal amount, for while the healthy infant will readily deal with a milk mixture containing 6 or 7 per cent., this is too much for the infant suffering from enteritis, especially if the condition has been one of any duration. Three per cent. of lactose is quite sufficient, and in some cases it may be advisable to give any added sugar in the form of dextrose. The administration of this substitute should, however, always be regarded as a submission to the immediate necessities arising from the abnormal and pathological condition. Lactic acid is laxative in effect, and the irritated mucous membrane requires to be protected by reducing the lactic acidity. Caseinogen must at first be either entirely withheld or

[1] *Vide* 'The Stools in Infancy,' by John Lovett Morse, M.D., *New Orleans Medical and Surgical Journal*, August, 1910.

administered in very small amount. The following prescription represents the type of food for a young infant suffering from simple enteritis, it being understood that albumin-water or a little sugar and water should be the food for the first twenty hours of treatment:

	Per Cent.
℞ Fat - - - - -	1·00
Lactose - - - -	3·00
Dextrose - - - -	3·00
Whey proteins - - -	0·50
Caseinogen - - -	0·15
Alkalinity - - -	5·00

As the enteritis yields, the food must be gradually adjusted, step by step, till it reaches the normal standard. But the practised clinician will proceed very carefully in this direction. It may be worth while to draw the reader's attention to the fact that, in the mixture prescribed, the total solids only amount to 7·65 per cent., and that of this total 6 per cent. is contributed by the sugars, leaving 1·65 per cent. to be divided among the fat and the proteins.

In a comparatively mild case, such as is very frequently met with, where the intestinal irritation has been of short duration, the treatment as outlined above may be all that is needed, and it cannot be too strongly insisted upon that drugs should not be administered unless they are really required. The routine administration of powders, carminatives, etc., cannot be too strongly condemned. The disorder is a diet disorder and should be so treated.

On the other hand, this argument must not be pushed to extremes. Where there has been prolonged intestinal inflammation, the whole alimentary tract is in a catarrhal condition, and the infant needs help. The intestine is so atonic that flatulence and colic constantly distress the infant; the inflamed mucous membrane is too irritable to be able to deal with the food materials, and is so sensitive that peristalsis is intensely exaggerated, and thin watery

evacuations occur with great frequency. The maxim that it is of no use putting new wine into worn-out bottles is not without its application. Something must be done, if it be possible, to bring the intestine into a condition in which it is capable of some approximation towards its normal function. A variety of therapeutic remedies are commonly recommended, such as bismuth, bicarbonate of soda, mercury and chalk, etc. They are all 'admirable remedies'—in the cases where the patient would do quite as well without them. In the case that really requires drugging they are entirely useless. There is one drug that is efficient, and, according to the author's experience, there is none that can replace it. Because it is really effective, it is also dangerous when administered without judgment. Opium is a very dangerous drug for infants. In very small doses it may cause the death of the infant, and, before describing the precise method of administering opium in enteritis, it may be well to draw attention to the following general rules:

1. Opium is too powerful in its effect on infants to be given in the crude form, in powders, or in any of the stronger standard solutions, such as the tincture of opium.

2. It should only be administered in a vehicle in which the opium has been so many times diluted that the amount of opium is minute.

3. The opium so ordered should always be in a separate 'opium mixture.'

The last rule is important, because the person administering the opium should always realize that it is opium. If it is included in a prescription of various drugs, the fact that the mixture contains opium may either be overlooked or insufficiently appreciated. By far the best preparation is the Tinctura Camphoræ Composita, and the usual dose for an infant of from three to six months of age is 1 minim, which is equal to $\frac{1}{240}$ grain of opium. It is usually prescribed by the author with dill-water as

the vehicle—1 minim to the drachm. This may be given with safety three times a day, and the dose of Tr. Camph. Co. may be increased to 2 or 3 minims if the case is carefully watched.

In most cases the drug is invaluable. It relieves the colic and flatulence, and calms the infant so that it not only sleeps, but sleeps restfully; it powerfully checks the irritable peristalsis, greatly diminishes the watery secretion from the bowel, stimulates the infant so that it loses its pallor and the cheeks and lips have more blood in them. In some cases it may be followed by a depressant effect, the patient being weak and drowsy. Brandy may be administered at the same time as the opium to check this; the following prescription is sometimes more efficacious, as in some cases brandy causes restlessness:

℞ Spts. menth. pip.	- -	♏$\frac{1}{4}$
Spts. chloroform.	- -	♏$\frac{1}{2}$
Aquam anethi. -	- -	ad℥i.

This may be given at fairly frequent intervals—every two or every four hours.

Irrigation of the Colon.—In most cases of enteritis colon-irrigation is extremely beneficial. It is carried out as follows: The apparatus consists of a douche can capable of holding a quart, rubber tubing, and a rectal tube. The fluid should be normal saline solution, and its temperature 100° F.

It is important that the buttocks should be elevated, so as to encourage the flow of the fluid into the colon. This is best effected by laying the infant on a table and bringing the buttocks, elevated by pillows, to the edge.

In order to prevent injurious hydrostatic pressure, the douche can should be very gently raised, and the elevation should not be greater than necessary to permit of a gentle flow of the solution into the colon. No attempt should be made to pass the tube past the rectum until the fluid flows readily; as soon as this occurs, the tube should be passed

into the colon to the extent of about 12 inches from the anus. Without the previous distension by the flowing fluid, the tube almost invariably doubles upon itself in the rectum.

The length and shape of the sigmoid flexure render it necessary that the tube should be passed slowly, in order to allow of its adaptation to the curves. It is not necessary that the tube should be introduced farther than the termination of the descending colon. If this is accomplished, the whole colon from the cæcum downwards is flushed out; if not, only the sigmoid flexure or rectum is reached. This limited irrigation is of little avail.

In infants of six months of age and older, at least a pint may be introduced before any of the solution returns. When this amount is retained, it is an indication that the solution has reached the colon. As the solution continues to pass, from time to time gushes of fluid issue from the rectum; but the irrigation should not be discontinued until the washings return quite clear. When this is accomplished, the tubing should be disconnected from the rectal tube, and this should be left in the colon for a time, in order to allow of the escape of any fluid that has been retained. In from half an hour to two hours this fluid will have been voided, and the tube may then be removed.

As a rule, not less than 4 pints of the solution should be used, and frequently this amount may be doubled with advantage, the test being the condition of the returning fluid. During the early part of the procedure, gentle massage or kneading of the abdomen facilitates the passage of the fluid into the colon.

In chronic enteritis where there is much mucus in the dejections, it is good practice to repeat the irrigation every twenty-four hours, until the indications for its use have ceased. In cases of urgency, where the symptoms of intestinal poisoning are acute and extreme, the irrigation may be required two or three times in the first twenty-four

hours. In these cases, and in others where collapse and prostration are marked, the temperature of the fluid may be raised with good effect to 105° F., or somewhat higher; it should not, however, exceed 110° F.

Thus, by purely physical means, a large and important part of the alimentary tract may be treated with results much more satisfactory than could be attained by drugs. Moreover, evacuation of the colon almost invariably results in a greatly increased peristaltic activity of the small intestine, and thus further facilitates the elimination of the irritant material.

In the most extreme cases of enteritis, where the evacuations are large, frequent, and watery, colon irrigation may be dispensed with. It may intensify the collapse, and, since the dejections are already so frequent, the chief indications for its use are absent. Its greatest use is seen in the chronic enteritis, or 'ileo-colitis,' where the dejection contains masses of mucus or shreddy material. The author has found normal saline solution the most satisfactory fluid for use. In some cases a considerable portion of the irrigating fluid is retained, often with marked benefit to the patient, and it is therefore important that the fluid used should be entirely innocuous.

The following case illustrates the dietetic treatment of enteritis, and illustrates the severe injury to the whole of the digestive machinery resulting from improper diet, especially when the food is systematically cooked. In all such cases the atrophic element is a prominent feature, with the result that recovery can only be gradually established. Such an infant as this is typical of the conditions antecedent to acute intestinal toxæmia. Had the acute disease supervened, the infant would probably have succumbed in the course of twenty-four hours.

J. T. (R. 1845), aged four and a half months. Not breast-fed at all. Fed on cow's milk (boiled) and water, then on cow's milk (boiled) and barley-water, then on sterilized milk. Intestinal dejections extremely frequent, green, and lumpy, with masses of curd

and mucus, and extremely offensive. For the last week continuous diarrhœa.

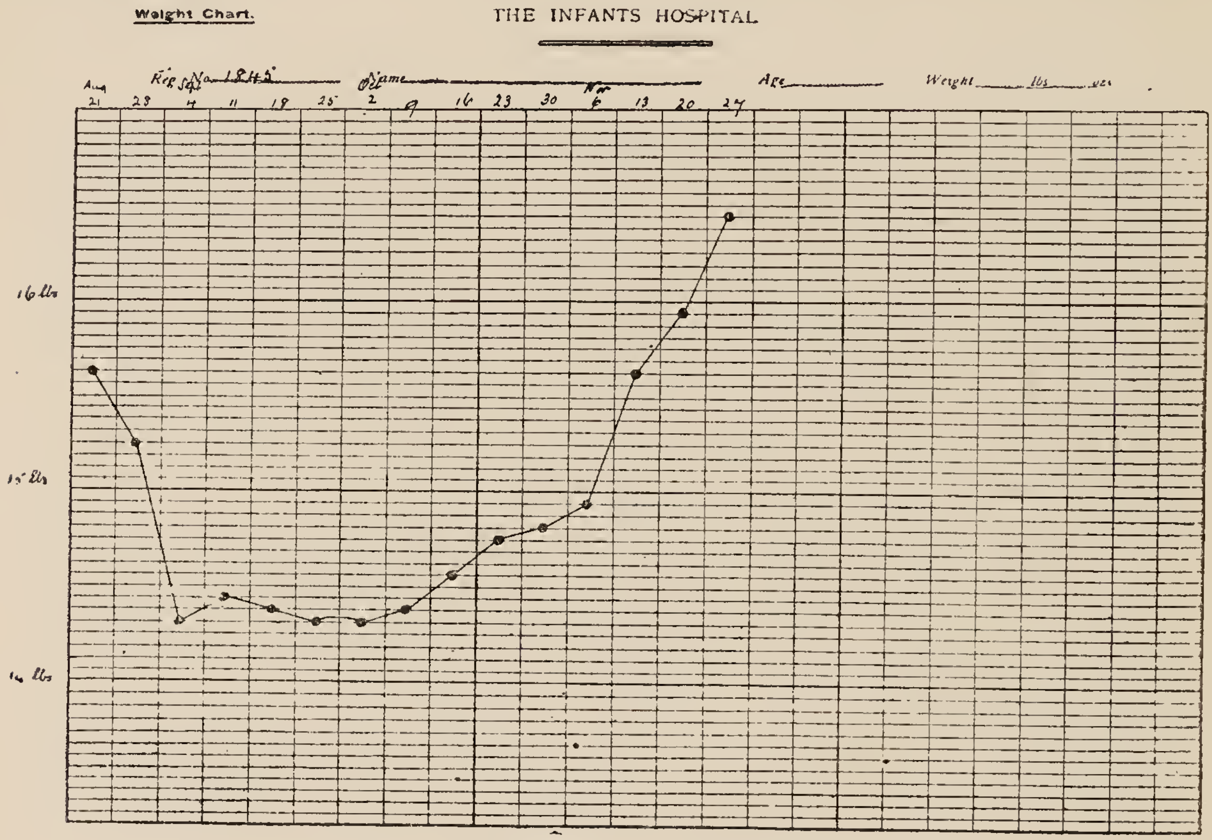

FIG. 47.—ENTERITIS. WEIGHT CHART.

Date.	Fat.	Lactose.	Whey Proteins.	Caseinogen.	Whole Proteins.	Feeds per Diem.	Amount in Ounces.	Remarks.
Aug. 21	Lactic culture, 4 ounces *statim.* Albumin-water, 2 ounces per feed.							
„ 22	0·50	5·00	0·50	0·10	—	6	4	Alternately with albumin-water.
„ 26	,,	,,	,,	,,	—	12	4	Albumin - water discontinued.
„ 28	1·00	6·00	0·50	0·25	—	12	4	
Sept. 2	1·25	6·50	0·50	0·25	—	12	4	
„ 9	1·50	6·50	0·50	0·50	—	8	5	
„ 16	1·75	6·50	0·50	0·75	—	7	6	
„ 23	2·00	6·50	—	—	1·00	7	6½	
„ 30	2·00	6·00	—	—	1·25	7	6	
Oct. 9	2·50	6·00	—	—	1·25	7	6	
„ 16	2·50	6·00	—	—	1·50	7	6	
„ 26	2·50	6·00	—	—	1·75	7	6	
Nov. 4	2·75	6·00	—	—	2·00	7	6	
„ 9	3·00	6·00	—	—	2·00	7	7	
„ 11	3·25	6·00	—	—	2·25	7	7	

ENTERITIS. DIET FROM AUGUST 21 TO NOVEMBER 11.

The Character of the Mother's Milk.—In reference to digestive disorder in the infant fed by its mother, nothing is more important than that the precise character of the milk supplied to the infant should be known. A sample of milk should be obtained by means of the breast-pump under strict precautions, and the specimen should be analyzed. The fact that the mother is herself well and that she is supplying a sufficient amount of milk must not be regarded as rendering this examination unnecessary. In some cases several analyses may be required. It is sometimes found that the milk of the mother varies greatly, occasionally agreeing with the infant, sometimes causing the greatest disturbance. These variations almost always correspond with the habits of the mother. The following summary of a case illustrates some of the important factors:

The milk in the middle of the second week was analyzed, and found to contain:

	Per Cent.
Fat - - - -	3·25
Lactose - - - -	6·50
Proteins - - - -	1·60

At this time the infant was doing well, and the analysis was made in accordance with the author's usual practice in the management of lactation.

At the end of the third week the mother had a violent dispute with one of her servants in the temporary absence of the nurse, and, being of a nervous temperament, was greatly upset. The next day the infant was suffering severely from colic. The motions were green, and there was considerable regurgitation of sour curds. The analysis of the milk showed a profound alteration in its character:

	Per Cent.
Fat - - - -	1·25
Lactose - - - -	6·00
Proteins - - - -	4·50

As soon as the symptoms in the infant appeared, it was removed from the breast and placed on a substitute food corresponding to the normal milk of the mother. The mother was then treated

by diet, exercise, etc., and a further analysis at the end of a week demonstrated that her milk was of a suitable character. The infant was again breast-fed, and did well. On one or two later occasions some difficulty was experienced, as the mother was apt to excite herself unduly ; but the disturbances were of a temporary character, and the infant was fed by its mother until it was weaned at the end of the sixth month.

The characters of the disorders arising in breast-feeding have been previously discussed in reference to the management of lactation.

Bacteriological Diagnosis.—In all cases of serious intestinal disorder dealt with by thè author a bacteriological analysis is made. In this way the diagnosis of the precise nature of the affection is greatly facilitated, while further examinations made during the treatment of the case enable the changing conditions to be adequately appreciated. In the more serious conditions the treatment by cultures of organisms specifically antagonistic to the toxin-producing bacteria is essential to a full recovery. Three classes of organisms are commonly observed in the intestinal dejections:

1. *Obligate Fermentative Organisms.* — These cannot attack the proteins; they produce lactic acid by their fermentative action on the carbohydrates, and they do not produce gas. The *Streptococcus lacticus*, the lactobacillus (Massol), and the *Bacillus acidophilus*, are the typical organisms.

2. *Facultative Fermentative Organisms.*—The whole colon group, of which the *Bacillus coli communis*, *Bacillus acidi lactici*, and *Bacillus lactis aërogenes* are prominent representatives, belongs to this class. They ferment carbohydrates, with the production of carbon dioxide and alcohol. Acting in this manner, they co-operate to a certain limited extent with the obligate fermentative organisms. In the absence of carbohydrates, or in conditions unfavourable to carbohydrate fermentation, these

organisms become proteolytic, and are thus facultative putrefactive organisms.

3. *Obligate Proteolytic Organisms.*—These have no action on the carbohydrates, but act entirely on the proteins. They can only act in the absence of carbohydrate fermentation. In these conditions they sometimes act in conjunction with the colon group. The *Bacillus subtilis*, *Bacillus mesentericus*, and *Bacillus proteus vulgaris* are typical organisms of this group.

In the healthy infant the biochemical processes occurring in the small intestine are largely controlled and determined by the *Streptococcus lacticus.* This organism is essentially dependent upon milk, is non-proteolytic, produces a moderate degree of acidity, and by its growth exercises an extremely powerful action in preventing the growth and action of all other organisms. In the lower part of the small intestine it does not grow at all freely, and in the large intestine it, as a rule, does not grow at all. Corresponding with the cessation of activity on the part of the streptococcus, the colon organisms, such as the *Bacillus acidi lactici*, *Bacillus lactis aërogenes*, *Bacillus coli communis*, come into action. But in health the action of all these organisms is fermentative—*i.e.*, their action is exerted on the carbohydrates, with the consequent production of lactic acid.

The natural diet of the infant is the ideal diet in regard to its determining influence on the nature and behaviour of the intestinal flora. On such a diet the *Streptococcus lacticus* flourishes, and in consequence the growth and behaviour of other organisms is strictly controlled.

The essential feature in the bacteriological examination is the accurate appraisement of the character and action of the organisms dominant in the intestinal tract. The details in regard to the bacteriological technique are necessarily too complicated to be dealt with here. Practical and systematic work in the laboratory, dealing with all

varieties of the normal and abnormal, is the only means by which any useful knowledge in regard to the biochemical processes occurring in the alimentary canal can be obtained. At the present time the morphology of the bacteria and their characteristics when grown on highly artificial media have bulked so largely in bacteriological literature that matters of fundamental importance have been almost completely neglected. The first essential for the student embarking upon a study of the action of bacteria in the alimentary canal is to put away from him all those conceptions or misconceptions involved in the term 'specific pathogenic organisms.' The colon bacillus growing in the large intestine in the healthy infant is entirely innocuous. The same organism growing in the intestine in a food-mixture more comparable with peptone broth than with milk may render the infant so ill that it is comatose.

Obviously, therefore, the bacteriological diagnosis must not only include the recognition of the organisms acting in the intestine, but the nature of their action.

One case may be cited in illustration. The author was consulted in reference to a child three years of age. For two years she had been constantly ill. There was great languor. She could not walk at all, and was barely able to stand. The appetite was extremely poor. There was marked anæmia ; both spleen and liver were enlarged, and moderate diarrhœa was a constant feature. Examination of the intestinal dejections showed a marked colon toxæmia. The organism was highly proteolytic and extremely virulent, and it showed marked capsulation, which is frequently seen in virulent colon organisms (Fig. 37, Plate XV.).

This child was quite unable to take milk, as it produced violent disturbance. The author ordered a diet consisting chiefly of milk, but with every meal a culture of the *Streptococcus lacticus* was to be given. The child's

progress was rapid. The appetite was restored in the course of a few days, and in a month or two she had made such improvement that most of the signs of her long illness had disappeared.

Many other cases could be cited with a very similar history; but this one case serves to emphasize the importance of the bacteriological diagnosis and treatment in cases of gastric and intestinal disorder. This child had been for more than two years under treatment by various physicians before she was seen by the author. But no treatment, dietetic or medicinal, was of any avail, for the dominating factor was an intestinal toxæmia arising from the action of the colon organisms, and this had entirely eluded diagnosis. The refusal of food was the child's natural method of protecting herself, for unless the toxin-producing organisms could be controlled, increase of food only meant increased toxæmia. As a result of the strange and bizarre diets received by infants and children at the present time, a very large number of the young population are affected to a greater or less degree by some form of alimentary toxæmia. In a good many cases, while there is constant ill-health, there is some degree of acclimatization, so that the child becomes, to some extent, toxin-tolerant. But the acclimatization is at best very inadequate, and the child is always in a dangerous condition.

In all cases of continued intestinal disorder a bacteriological examination should be made. If this is not done, both diagnosis and treatment are essentially inadequate and empirical.

CHAPTER XIV

ACUTE INTESTINAL TOXÆMIA

ACUTE INTESTINAL TOXÆMIA[1] is the most fatal disease of infancy, and, despite the advances which sanitation has made in this country, no corresponding improvement is observable in the infant mortality rates. On the contrary, it has been clearly shown by Newman that Epidemic Diarrhœa (the official name of the disease) is steadily increasing as a factor in the causation of death among infants under one year of age. He contrasted the death-rates of infancy in the years 1845-1849 with the rates for the years 1899-1903, the figures being derived from the Registrar-General's Reports for the two periods. These figures show that the deaths arising from epidemic diarrhœa and from conditions of immaturity at birth have greatly increased.

'Diarrhœa, which formerly caused the death of 10 per cent. of dead infants, has increased in half a century to 15 per cent.; respiratory diseases have risen from 16 to 18 per cent.; and prematurity from 17 to 29 per cent. . . . Other children's diseases are vanishing or have vanished.

[1] This chapter is chiefly based upon the author's experimental investigations at the Infants Hospital and the Lister Institute. A detailed account of the experiments will be found in his 'On Acute Intestinal Toxæmia in Infants: An Experimental Investigation of the Etiology and Pathology of Epidemic or Summer Diarrhœa.' London, 1911.

There has been a vast improvement in the general environment surrounding their lives, but the problem of infantile mortality still remains because of the *increase* in these diseases—prematurity, pneumonia, and diarrhœa.'[1]

The group of conditions broadly indicated by the terms immaturity, prematurity, or congenital defect, are of great importance, for they show that antenatal conditions are responsible for a large proportion of deaths occurring in infancy. These deaths are sharply distinguished from those arising from causes that affect the infant after birth by the fact that the deaths arising from congenital defect occur for the most part in the first few weeks of life, and practically all of them within the first three months.

The great increase in the proportion of deaths caused by epidemic diarrhœa cannot, however, be so accounted for. The disease may attack the infant at any age, but its greatest intensity of attack is not exercised upon the youngest infants, but upon infants between the ages of four and eight months. The increase in the proportion of deaths from respiratory diseases is probably closely connected with the increase in diarrhœa. Healthy infants are not very frequently attacked by serious disease of the lung as a primary affection. In a certain number of quite young infants a subacute bronchitis may be observed. It is very chronic in character, and it is generally stated to have been present at birth or soon afterwards. This is the common type of bronchitis in infants who are born the victims of congenital syphilis.

In conditions of enteritis, pneumonia is extremely likely to develop as a complication. It occasionally occurs in the acute disease, but it is commonly seen accompanying the more chronic conditions. It is a frequent accompaniment or sequela of atrophic enteritis, and many

[1] 'Infant Mortality,' pp. 55, 56.

infants suffering from this disease contract pneumonia as a terminal affection.

With regard to acute intestinal toxæmia, it is necessary to lay stress upon the fact that the disease is an extremely acute one, and is widely removed in its clinical characters from the chronic digestive derangements from which infants commonly suffer as the result of improper feeding.

The necessity for insisting upon this discrimination is shown by the confusion which exists amongst various writers, and which is well illustrated in a series of cases recently published. Some of the cases appear, from the account, to be clearly cases of 'epidemic diarrhœa'; others are almost equally clearly not instances of this disease. Indeed, one infant is described as weighing 14½ pounds at five months of age, and as having suffered from epidemic diarrhœa *since birth.*

The infants most liable to suffer from the disease in its most violent and fatal form are those in whom alimentary disorders have been established for some time. Their condition is one in which the organisms immediately causing the disease find their unfettered opportunity. In some cases it may be difficult to establish the line of demarcation between the simple and the toxic enteritis; nevertheless, the clinical types are essentially distinct. The disease is so fatal that the consideration of its etiology and of the methods by which it may be prevented is of much greater moment than that of the precise therapeutic measures to be adopted when the infant is attacked. For, with the most expert treatment available, the recovery of the infant is in reality dependent upon the dose of poison it has received, the precise degree of virulence of the poison, and the constitutional vigour of the infant.

It therefore becomes necessary to examine the evidence available as to the causation of the disease. Elaborate researches have been carried out by various authorities,

with the result that the following facts are clearly established:

The disease is most prevalent and most fatal during the third quarter of the year. The higher the temperature of the late summer, the greater the prevalence of the disease, especially if this high temperature be associated with but little rain. In other words, meteorological conditions involving a high temperature with much dust are those which promote the conditions which accompany the greatest incidence of the disease.

The classical researches of Ballard,[1] the more recent researches of Newsholme,[2] and the observations made by many Medical Officers of Health, all establish clearly that the essential factors are high temperature and dust, with special reference to the part they play in the contamination of milk. Three of Newsholme's conclusions are of particular importance:

1. Epidemic diarrhœa is chiefly a disease of urban life.

2. Epidemic diarrhœa as a fatal disease is a disease of the artisan and still more of the lower labouring classes to a preponderant extent. This is probably largely a question of social status *per se*; that is, it is due to neglect of infants, uncleanly storage of food, industrial occupation of mothers, etc.

3. The fundamental condition favouring epidemic diarrhœa is an unclean soil, the particulate poison from which infests the air and is swallowed, most commonly with food, especially milk.

The following are the conclusions formulated by Ballard in 1887 'as a working hypothesis that would best accord with the totality of the evidence':

'That the essential cause of diarrhœa resides ordinarily in the superficial layers of the earth, where it is intimately associated with the life-processes of some micro-organism not yet detected, captured, or isolated.

[1] Supplement to the Report of the Medical Officer of the Local Government Board, 1887.

[2] *Public Health*, 1899-1900.

'That the vital manifestations of such organism are dependent, among other things, perhaps principally upon conditions of season and on the presence of dead organic matter which is its pabulum.

'That on occasion such micro-organism is capable of getting abroad from its primary *habitat*, the earth, and having become air-borne, obtains opportunity for fastening on non-living organic material, and of using such organic material both as nidus and as pabulum in undergoing various phases of its life-history.

'That in food inside of, as well as outside of, the human body, such micro-organism finds, especially at certain seasons, nidus and pabulum convenient for its development, multiplication, or evolution.

'That from food, as also from the contained organic matter of particular soils, such micro-organism can manufacture, by the chemical changes wrought therein through certain of its life processes, a substance which is a *virulent chemical poison;* and that this chemical substance is, in the human body, the material cause of epidemic diarrhœa.'

The facts thus ably elucidated by these observers are incontrovertible, and it becomes necessary to carry our inquiry a step farther, and elucidate, if possible, the precise character of the poison which is responsible for the disease, and the manner in which it is conveyed to the infant.

In the first place, it is essential to the comprehension of the disease that the common conception that it belongs to the group of specific infectious diseases should be abandoned. Epidemic diarrhœa is in no sense of the word an infectious disease, and it cannot be conveyed by contagion.

It should be noted that Ballard carefully refrained from using the word 'infection,' and laid stress on the essentially toxic nature of the disease.

The work of the Infants Hospital is confined exclusively to infants under twelve months of age. All the infants

when admitted are seriously ill, most of them desperately so. At the times that the disease is prevalent, very numerous cases are admitted, mostly of an extremely severe type. No infant has ever contracted the disease in the hospital. The only infants suffering from epidemic diarrhœa are those suffering from the disease at the time of admission. No attempt at isolation is made. The infants lie side by side in their cots—the case of severe atrophy next the case of epidemic diarrhœa—and they are all tended by the same nurses, who minister to all their requirements. All the infants in each ward are bathed in the same bath-room.

Precisely the same thing is seen outside the hospital. At a time that the disease is sweeping through a town, destroying some hundreds of infants per thousand in the course of a month or two, there are babies living in the most insanitary conditions who are immune. They are the breast-fed babies. There is no need to labour this point, for numerous Medical Officers of Health have drawn attention to the same fact.

Between the circumstances of the poor Irish breast-fed baby living in a London slum and those of the infant warded in the Infants Hospital there is a wide contrast. There is also a remarkable correspondence. Both are fed on a pure *raw* milk. The infants at the hospital are protected by something much more powerful than isolation, for it is a practical impossibility for the violent fatal disease—epidemic diarrhœa—to occur in an infant fed on fresh milk. It is essential for the development of the disease that the characteristic properties of the natural food of the infant should have been destroyed by heat, by preservatives, or by some other means.

The proper care of milk implies that it shall be handled in such a manner that the development of all organisms in the milk is prevented, whether they be beneficent or otherwise. But even when milk is not guarded so care-

fully as this, it is protected by its peculiar qualities from decomposition in the ordinary sense of the word. Milk left to itself at ordinary temperatures undergoes a chemical decomposition peculiar to itself. The lactose is converted into lactic acid by means of the lactic acid bacteria, and when the production of the acid has reached a certain point the caseinogen of the milk is coagulated, the action of the acid being exactly the same as regards the precipitation of the curd as that of any other acid—acetic, hydrochloric, etc.

In the case of infants fed on milk that has undergone this lactic decomposition, digestive disturbance is extremely likely to occur and diarrhœa is almost certain to ensue. But the affection is altogether different from the conditions seen in epidemic diarrhœa. (1) The diarrhœa is 'simple'—*i.e.*, it is due to an excess of a constituent normally present in the alimentary canal; (2) appropriately treated, the infant will soon recover; (3) there is a complete absence of the *toxæmia* which is the characteristic and fatal feature of the acute disease.

Such conditions, however, ought to be prevented, and the fact that milk is not in a fit condition for consumption can be readily detected, owing to the characteristic smell of lactic acid, even when this has only been formed in very small amount, so small that it is insufficient to curdle the milk. When the milk has not been cooked there is therefore a natural danger-signal, indicating that it is not sufficiently fresh.

The fundamental character of this reaction is that it entirely prevents any changes occurring in milk of a poisonous character. Moreover, the production of lactic acid is by no means unlimited. When the amount of acid produced has reached a certain point (considerably less than 1 per cent.), the lactic bacteria are inhibited, and thus a condition is reached in which no further development of lactic organisms can occur, while no other

organisms can develop, since these require an alkaline or neutral medium.

One of the most unfortunate facts in regard to the disease is that it should be named officially by a symptom. The intensity of the diarrhœa affords no criterion of the severity of the disease. On the contrary, the worst cases, as a rule, are those in which diarrhœa is not a prominent symptom or is entirely absent. Emmett Holt, in his 'Diseases of Infancy and Childhood,' particularly refers to the cases in which constipation occurs, and he adds that when one meets such a case he can appreciate the fact that in acute intestinal intoxication diarrhœa is a conservative process of the greatest possible value. Ballard, in 1887, stated that in his opinion the disease could run its course from first to last, and even to death, without any diarrhœa at all. In the author's experiments on kittens, diarrhœa was extremely variable in its occurrence.

For the incidence of acute intestinal toxæmia certain general conditions must obtain in regard to the diet of the infant.

The milk must be boiled (pasteurized or sterilized), or so treated by heat, or by preservatives, or by some other means, that the lactic organisms are either destroyed, or their action inhibited.

The determining point in the incidence of the disease is the failure of the stomach and the intestine to maintain the acid reaction of its contents. Directly this fails the putrefactive organisms proceed to actively live and develop in the alimentary canal. A complete revolution of the normal processes is thus attained. Being actively motile, the metabolism of these organisms is rapid and extensive, and the immediate products of their metabolic activity are absorbed from the intestine, and produce paralysis, coma, and death in the individual attacked. The toxic products are not present in the culture medium,

for the proteolytic changes carried out consist of a series of stages by which protein matter is converted into soluble nitrogen containing material suitable for absorption by the vegetable kingdom. At a very early stage in the process poisonous bodies belonging to the most powerful group of poisons we know of—the alkaloids—are produced. But these, apparently, only exist in the initial stages of putrefaction, and, in the putrefactive changes occurring outside the body, are speedily decomposed into substances which exert no poisonous action.

The disease may therefore be described as a disease directly caused by the absorption of poisons produced by the action of certain micro-organisms whose normal function is the dissolution of dead organic material. These organisms, while always present in the healthy alimentary canal, are, under normal conditions, quite unable to carry out this function, since they are inert in an acid medium. The essential cause of the disease is the inability of the infant to protect itself from the action of these organisms, owing to its food being so altered from its normal character that the necessary supply of acid cannot be maintained. As soon as this supply fails the disease arises.

Since the condition of the milk with regard to the lactic organisms is the essential point, the other means by which their action may be prevented require to be mentioned. When the milk mixture prepared for an infant is made from raw milk, the mixture may comply to a greater or less extent with the specified conditions in certain circumstances. In the preparation of the food of the young infant, cow's milk is considerably diluted, equal parts of milk and barley-water, supplemented by a little cane-sugar, being a common mixture. If this mixture is made in bulk from boiled milk, and is allowed to stand for some considerable time, the danger in hot and dusty weather is extreme. But even when made from raw milk

the danger is always present, for the growth of the lactic organism depends upon the presence of lactose; in the diluted mixture the amount of lactose is much reduced, and consequently the production of lactic acid is much diminished; while the barley-water directly or indirectly favours the organisms dangerous to the infant. Apart from the above treatment, nearly all methods commonly employed in the domestic preparation of the infant's food favour the development of putrefactive organisms. Other factors not directly concerned with the handling of the milk prior to administration predispose to the disease. Many infants suffer seriously from chronic indigestion, in consequence of the mass of casein which their gastric and intestinal secretions have to deal with. Even in such a commonly used mixture as equal parts of milk and water, the casein is present in a proportion about three times as great as in the food received by the healthy infant when breast-fed. As a result of this excess, the normal fermentations are greatly hindered. The bacilli common to the large intestine become more and more established in the small intestine, and the intestinal dejections in consequence give evidence of putrefactive changes. These are pre-eminently the conditions predisposing to the incidence of the disease.

Diluted condensed milk of the ordinary variety is probably the agent responsible for the disease in its most fatal and devastating form. Here, every condition has been fulfilled that the putrefactive organisms may acquire their fullest activity. The condensed milk when diluted contains so minute an amount of lactose as to render it a negligible quantity. The lactic organisms have been entirely destroyed, and putrefactive changes are the only changes that can occur.

Boiled milk is, however, the type of the food commonly used and fulfilling the conditions for the development of the disease, and it is necessary to consider the actual

resultant processes as they affect the infant belonging to the mother of the poorer classes.

The boiling effectually destroys the lactic organisms, but it makes no impression on the spores of the putrefying bacteria. Much higher temperatures and much longer exposure are required to kill these. It is the condition of the milk *after* the boiling that constitutes the critical and imminent danger to the infant. Even if the mother carefully employs the only method of cooling at all available to her, she has to reduce the temperature of the boiled milk by means of running water, which as it comes from the tap, in the summer, is at a temperature of about 70° F. This latter temperature is nearly the *optimum* temperature for the putrefactive organisms, so that their prolific and luxuriant growth inevitably ensues. In the process of transferring the milk from the saucepan to a jug or other vessel in which the milk is to be kept occurs the first contamination after boiling. The mother may cover the milk with a saucer or by some other domestic means, but it is practically certain that dust will find its way to the milk, when the circumstances of the poor home are considered. Moreover, the frequent intervals of feeding render the liability to contamination extreme. Within two or three hours the milk will again be thoroughly exposed, in order that the next feed may be prepared, and thus the increase of putrefactive bacteria and their poisonous products proceeds throughout the day.

The simple fact is, that if a bacteriologist were asked to state the measures necessary to convert a safe milk into one which was a virulent poison, he could not greatly or essentially improve upon the method as carried out by the mothers of the poorer classes at a time when the temperature is 80° F. in the shade, and dust and flies are everywhere.

It cannot, however, be too strongly emphasized that these organisms of putrefaction do not directly produce

the disease. Even when myriads of them reach the alimentary canal of the infant, as they do in contaminated boiled milk, they are still quite unable directly to attack the infant. They are unable to live in the tissues of the living body. Their action is one which is exercised entirely upon the milk, either inside or outside the infant.

The changes they produce in milk are the changes directly connected with their essential function as putrefactive organisms. They act upon the albuminoids as albuminoid-dissolvers, and create, by their action upon these constituents, virulent chemical poisons. It is these chemical poisons which develop under the conditions that have been described, which produce the toxæmia characteristic of the disease, and which are so virulent that they destroy the infant in the course of a few days by their poisonous action upon the cellular tissue throughout the body.

The effective cause of intestinal toxæmia is not the organisms which finally promote its production, but the methods by means of which the infant has been deprived of its natural safeguards against them.

The fundamental characteristic of the natural food of the infant is that it is a raw fluid. In all circumstances the cooking of milk for the use of infants gravely impairs its nutritive value. With regard to acute intestinal toxæmia, no serious amelioration in the mortality arising from this disease can be anticipated until the fullest protection of pure raw milk is secured for every infant, and special precautions must be taken, at times when heat and dust are prevalent, to secure that the milk for the use of infants shall be preserved fresh and unboiled.

Onset.—While the disease itself is extremely acute, it comparatively seldom arises in an infant absolutely healthy. The infants most frequently attacked and succumbing most quickly to the disease are those in whom intestinal disorder has existed for some time; for although the development of the toxins producing the disease may occur to

some extent, outside the body, the extreme virulence of the disease is seen in those cases where the putrefactive organisms can not only act upon the milk prior to consumption, but are still capable of maintaining their functions inside the alimentary canal. This can only occur when the normal acidity of the small intestine has largely or entirely disappeared. Consequently the infant, in the majority of cases, has been ailing for a considerable period before the incidence of the acute disease. In the summer, prior to the onset of the hot weather, especial precautions should be taken to secure that the intestinal conditions are healthy. All symptoms of enteritis, as described in the previous chapter, should be immediately and thoroughly treated.

Symptoms.—The onset of the disease is, as a rule, characteristic. The infant is extremely restless and exhibits signs of distress. The temperature rises rapidly till it reaches 103° or 105° F., and, as the temperature rises, the illness of the infant increases. Vomiting is one of the first signs to appear. At first, the vomit consists of undigested food; later, a watery fluid is vomited consisting of mucus and bile; while retching continues for some time after actual vomiting has ceased. As a rule, the vomiting ceases when the diarrhœa becomes established. At first the dejections are not widely removed in their character from the normal, but the intestine is distended with flatus which escapes in large volumes as the expulsion of the intestinal contents occurs. In a few hours the character of the dejections changes greatly: they become thin and watery, so that they do not differ greatly in appearance from dirty water; usually, they are intensely offensive. At this stage the evacuations may be so frequent as to be almost continuous. The infant is now in the throes of the disease; the face is ashy gray in colour, the eyes have lost their lustre and may be glazed. Thirst is intense, and the infant is comatose.

Treatment.—When the infant is not seen till it has

reached the condition above described, but little can be done to save it. An infant was seen one afternoon in the out-patient department of the Infants Hospital. It was doubted whether it would reach the ward alive, for death appeared to be imminent. In the ward restorative measures were rapidly applied, with the result that the infant rallied. But the rally was purely a temporary response to the stimulant treatment adopted, and after this it gradually sank and died the same evening. Such is the common history of many cases as they are seen in hospital practice. The first essential, therefore, is to impress upon all those concerned with the affection, that with the first appearance of the symptoms the treatment must be radical and immediate. The disease is so fatal that, even with the most effective treatment applied without delay, many deaths must occur. If the infant has suffered for twenty-four hours from the disease in its severest form without radical treatment, it is probable that it will die, however expert the treatment after this period.

In the circumstances in which the disease arises, the physician has to accept the fact that the alimentary canal is loaded with putrefactive material. He bases all his methods and any hope of success upon the question of the general toxæmia. If he can rid the infant of these putrefying materials within the alimentary canal with such rapidity as to prevent the absorption of a fatal dose of the toxins, the life of the infant will probably be saved.

Colon irrigation is therefore the essential treatment, and should be carried out thoroughly in the manner previously described (p. 248). In spite of the high temperature, the infant's body-surface may be cold, and the feet may be clammy. Small rubber hot-water bottles should be packed round the infant; they are much more effective than large rubber or earthenware bottles, as they can be packed close to the infant, so as to actively and rapidly provide the heat required

At one time subcutaneous injection of normal saline solutions was largely practised at the Infants Hospital. It has been almost entirely abandoned in favour of administration by the mouth. The patient, as a rule, takes it greedily, and there is none of the disturbance and exposure associated with injections. Given by the mouth in an ordinary bottle, it acts quite as quickly and certainly as effectively as when given subcutaneously. Lactose or dextrose may generally be added to the feed with advantage. No solid food of any kind should be given for at least forty-eight hours. The digestion is quite paralyzed; the intestine is in far too irritated a condition to tolerate the protein or fat of milk, and the prospects of the infant's recovery will only be prejudiced by their administration.

In regard to the toxæmia, the most effective treatment is by means of oxygen. It should be given freely, and in order to prevent the drying effect of the gas on the lips and mouth it should be passed through warm water. This may be effected by means of a glass funnel inserted into the rubber tubing, in the stem of which is placed moistened wool. It must be packed lightly, so that the egress of the gas is not seriously impeded. Where the toxic effect of the poisons is well marked, so that the tissue cells of the chief organs are definitely affected, it is doubtful if oxygen produces any serious improvement; but where this has not occurred to a serious extent, oxygen does effect a change in the general condition which is not obtained by other means.

In the first stages of recovery from the toxæmia and collapse, the greatest and most detailed attention is called for in regard to the treatment. The colour is much better, the infant is ravenously hungry, and the withholding of all milk produces a restlessness which in itself is sufficient to set up a renewed flux from the intestine. But the absolute suspension of all milk must be maintained, and the restlessness supervening on the first stage of recovery may be relieved by small doses of opium. If at the end of seventy-two hours the diarrhœa has ceased, the toxæmia

is disappearing, and the general condition has much improved, the question of administering food may be considered. At first it should be dilute albumin-water (the white of one egg to the pint). This should not be given at every feed, but only at alternate feeds, the other feeds consisting of a 5 per cent. solution of lactose or dextrose. In a further forty-eight hours the albumin-water may be gradually replaced by an extremely dilute milk mixture, such as is indicated in the following prescription :

	Per Cent.
℞ Fat - - - - -	0·25
Lactose - - - - -	4·00
Whey proteins - -	0·25
Caseinogen - - -	Nil
Alkalinity - - -	10·00

Relapse is extremely liable to occur, owing to (1) the weakened and sensitive condition of the intestine, (2) the injury to the protoplasm of the tissue cells, so that they are unable to maintain their metabolic functions. Immediately any signs of relapse occur, fat and protein should be withheld until the symptoms have disappeared.

In some of the acute cases, recovery is rapid, and in the course of a week or two the digestive functions rapidly regain their normal powers. These are usually cases where the infants have been in a healthy condition prior to the onset of the disease. In a large number of cases the acute attack has supervened upon a chronic enteritis, and after recovery from the acute toxæmia the infant is likely to die from exhaustion, since the injury to the intestine renders it unable to perform the normal digestive functions.

In this condition of chronic atrophic enteritis, pneumonia is not unlikely to develop, while in other cases cerebral irritation with convulsions may arise owing to the perverted nutrition of the central nervous system. In all such cases the prognosis is bad, as these complications indicate the final failure of the infant's resistance to the long-continued adversity of its environment.

CHAPTER XV

ATROPHY

INFANTILE ATROPHY (marasmus, 'wasting disease') is one of the common diseases of infancy, and is caused solely by improper feeding.

For the purpose of precise diagnosis and treatment, it is necessary that the nature of the disease and the relationship existing between its etiology and its clinical characters should be clearly understood.

The prevalent conception of the disease, as one peculiar and idiopathic, so that there is a condition of 'marasmus' or some inherent fault affecting the physiological constitution of the infant, by reason of which the infant wastes, is one fundamentally opposed to the facts as seen in the actual processes of the disease.

There are conditions, to be discussed later, which undoubtedly belong to the order of inherent defect or disease; their presence should serve at once to exclude the diagnosis of atrophy. The history of the gradual development of the atrophic condition and of all the physical signs and symptoms is quite characteristic. As much confusion exists at the present time in regard to the real nature of atrophy, it is necessary to elucidate the conditions under which the disease arises and develops.

The infant at birth is healthy and normally developed, of good weight and proper length. For the first month or two it receives nourishing food and thrives, so that in

this period it increases in weight and in length. This is an extremely important feature in the history, and if the evidence shows that, in a given case, the infant has in fact been failing from the time of birth, atrophy may certainly be excluded. After thriving for a period, the infant is then subjected to deprivation of the nutritive food, and is fed on materials altogether unsuitable and incapable of providing either the food needed by the tissues or the stimulus required by the digestive structures for their continued activity and development.[1] For in atrophy the processes of the disease are directly related to the character of the food received by the infant.

The infant suffering from atrophy is invariably a comparatively *large* infant, wholly different in its appearance from the miniatures of infancy characteristic of immaturity. The skeletal structures have at first developed normally, so that when, later, the infant wastes, the loss of the subcutaneous tissue gives rise to the appearance typical of the condition. This is simply the appearance presented by an individual when the skeletal structures have been deprived of the normal clothing provided by the soft tissues, and the likeness between infantile atrophy and the effects of old age is so pronounced because the physical conditions producing this appearance are the same in both cases. The photograph (Fig. 48) taken from an infant treated in the Infants Hospital shows the typical features of the disease, for, in addition to the extreme emaciation, it shows that the skeletal structures are much larger than those of the infant at birth. The size of the head, the hands, and the feet, affords clear evidence of this. The infant measured 24 inches in length when first seen, so that, prior to the onset of the disease, it must have increased in length by 3 inches since birth.

That it is not unnecessary to lay some emphasis on the

[1] *Vide* Pancreatic Secretion in Relation to the Precise Diet, *et seq.*, p. 186.

features belonging to the incidence and development of infantile atrophy is well shown by the confusion which at present exists. In the Registrar-General's returns of deaths among infants in the early weeks of life, 'atrophy' is given as one of the common causes of death. Death from atrophy in infants under four months of age is extremely rare; it is a chronic disease of some months' duration and seldom begins before the third month of life.

Fig. 48.—Atrophy.

J M., aged 7 months; weight, 7 pounds 10 ounces.

Congenital Defect. — The two conditions most frequently confused with atrophy are congenital deficiency and congenital syphilis. The presence of any degree of immaturity at birth is always sufficient to exclude atrophy, since the wasting of the infant is far from being directly related to the character of the food received. In a typical instance of congenital deficiency, where the defect is one inconsistent with the continuance of life for any considerable period, a characteristic feature is that the precise quality of the food makes little or no difference to the infant. Neither the mother's milk, nor that of a wet-nurse, nor a delicately graduated milk, is of any avail. A very dilute milk may disturb the infant less, while an extremely dilute condensed milk will probably cause even less disturbance, because it contains even less food. During intra-uterine life the fœtal tissues are nourished by the direct transference to them of tissue-food from the mother. The digestive structures play no

part in the creation of the food supplied to its tissues. The latest of all the stages of development is that of the digestive functions. In the most marked cases of immaturity, where the infant is under 18 inches in length at birth, these functions are nearly always absent, and the infant dies—because it cannot live.

These infants either die within a few days of birth, or they live—on their own tissues—for a period of from three weeks to two months. Death is as a rule attended by few symptoms of urgency. They gradually become weaker and partially unconscious; the actual incidence of death is not infrequently slow in its appearance, so that the infant lingers for several days, the point of death seeming continually imminent. In cases where the immaturity is less marked, and where the infant is not much more than 1 inch below the normal length, a better prognosis may be given, but it should always be a guarded one.

In all cases of immaturity, exceptional care over a period of many months is necessary; slight disturbances provoke serious effects, and the infants have but little rallying power. Even in the cases that make good progress, there are generally features serving to call to the recollection the fact that the infant at birth was not mature. In general, the teething will be late and difficult, walking will be unduly long in making its appearance, and speech may be greatly delayed.

Diet is of the first importance, because, unless everything possible is done to place the infant under the most favourable conditions for overcoming its deficient equipment of vitality, it will soon succumb. A typical instance of a comparatively mild congenital deficiency is seen in the following case.

B. J.—(R. 905) Female infant, aged seven weeks, was seen by the author in consultation with Dr. Luson, of Kingston-on-Thames. Some two years previously the mother had given birth to a markedly

immature infant. This infant the author had also seen, with Dr. Luson, late one evening, a few hours after birth. It died early the next morning.

The infant, the subject of the present note, was breast-fed for the first four weeks. As it was not thriving, the breast-feeding was abandoned and the infant was fed on a mixture of whey and cream. The infant still failed to thrive, and its condition now gave rise to considerable anxiety.

Careful examination elicited no evidence of disease. The infant was undoubtedly immature (though apparently born at full term), for it measured 19¾ inches.

The question as to whether the infant was capable of developing the functions of a normal infant was the question upon which everything turned. It was agreed, having regard to all the circumstances, that the infant should be immediately taken to the Infants Hospital. The history of the infant in the hospital is of interest in relation to the prognosis given, and serves to illustrate concisely and definitely the

Date.	Fat.	Lactose.	Whey Proteins.	Caseinogen.	Whole Proteins.	Feeds per Diem.	Amount in Ounces.
March 2	1·00	5·00	0·50	0·25	—	11	4
,, 3	1·25	5·00	0·75	0·25	—	11	4
,, 5	1·50	5·00	0·75	0·25	—	11	4
,, 12	1·75	5·50	0·75	0·25	—	11	4
,, 17	1·75	6·00	0·50	0·50	—	11	4
,, 21	1·75	6·00	0·75	0·25	—	11	4
,, 26	2·00	6·50	0·75	0·25	—	10	4
,, 31	1·50	5·00	0·75	0·25	—	10	4
April 7	1·50	5·00	0·75	0·50	—	10	4
,, 18	1·50	5·00	—	—	1·00	10	4
,, 21	1·75	5·50	0·75	0·25	—	10	4
,, 30	1·50	5·00	—	—	0·50	10	4
May 9	1·75	5·50	—	—	0·50	10	4
,, 12	1·75	6·00	—	—	0·75	10	4
,, 14	2·00	6·50	—	—	0·75	8	5
,, 19	2·00	6·50	—	—	1·00	8	5
,, 23	2·25	6·50	—	—	1·00	8	5
June 2	2·50	6·50	—	—	1·25	8	5
,, 9	2·50	6·50	—	—	1·50	8	5

CONGENITAL DEFECT. DIET FROM MARCH 2 TO JUNE 9, 1909.

characteristics of the infant suffering from congenital deficiency. Throughout its stay in the hospital the infant suffered from no digestive disturbance. It took its food well, there was no vomiting, no intestinal disturbance, and the dejections were normal. But for a considerable period it would not gain in weight; indeed, as the author wrote of the infant while it was still in hospital: 'It is a remarkable illustration of this class of case. The infant is taking a large amount of highly nutritious food, there is no digestive disturbance of any kind, and yet she makes absolutely no gain in weight. She has not yet reached the stage of development represented by structural creation.' A week or two later this development appeared, and the infant forthwith proceeded to gain satisfactorily.

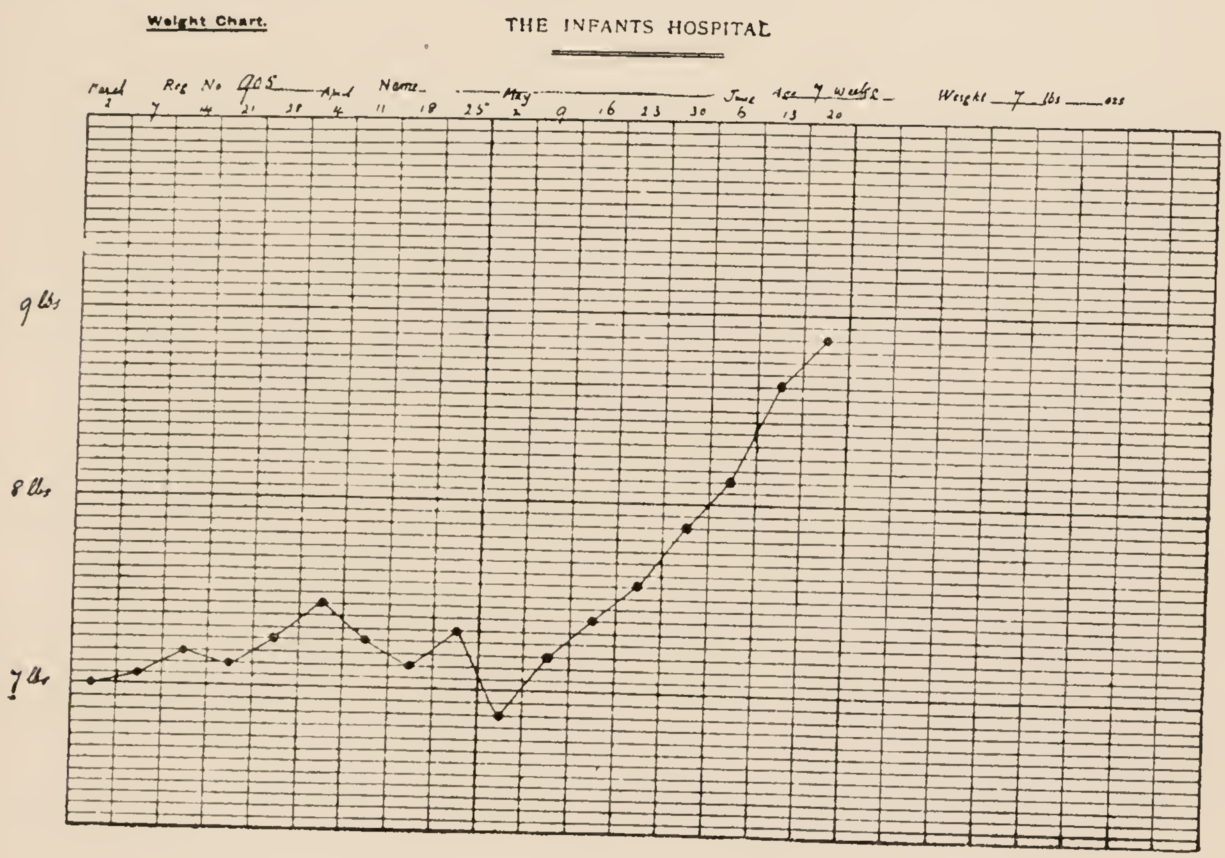

FIG. 49.—CONGENITAL DEFECT. WEIGHT CHART.

Congenital Syphilis.—Congenital syphilis is an affection of varied manifestations, and certain facts require to be considered, since they have a definite relation to the nature and incidence of the disease as seen in young infants. When the infection is recent and active, it affects the fœtus so severely that it dies *in utero*, and miscarriage or still-birth occurs. This represents the most acute stage of infection. The next stage is that in which the infant is born

alive and at full term, or approximately so, but manifests definite signs of syphilis at the time of birth. The infant is generally rather shrivelled, the skin is red and raw-looking, the body or the limbs are covered with pemphigus, and the cry is a hoarse wail. The whole appearance is widely removed from that of the healthy new-born infant. The prognosis is bad. Some cases presenting the least marked signs may survive, with expert treatment and management, but they are the exceptions to the rule. Infants manifesting undoubted signs of congenital syphilis at birth generally die in the course of three months. Frequently, they only live for a few days.

The third stage is that in which the infant at birth appears healthy. Very frequently it is remarkably healthy in appearance, the weight being good and the vigour exceptional. The specific symptoms soon begin to appear. The first symptoms, however, are not those generally recognized as syphilitic, for these are later in appearance. As a rule, the first signs are those manifested by the nervous system. The cry of the infant is generally characteristic. When well marked, it is so typical that the author has frequently made it his leading reason for the diagnosis. Clinical experience alone can convey an adequate idea of the character of the syphilitic cry.

The crying is almost continuous; there is a wildness and frenzy in the cry which removes it from the category of the ordinary infantile plaints, and conveys to those in attendance the impression that something must be wrong when the infant is so intense in its crying, or so 'mad' as a nurse once put it.

In these paroxysms, the infant but a few weeks old turns in its cot, and rolls its head from side to side, so that its restlessness is another prominent feature. Generally, sleeplessness is a fairly well marked feature. All these symptoms are produced by the action of the toxin on the central nervous system. At a slightly later stage the

general signs appear. Snuffles is a common feature, but, alone, it is useless in regard to diagnosis ; for many young babies, especially those suffering from malnutrition, exhibit this sign. A dull red rash appears around the buttocks, in the flexures, on the chest and abdomen, and not uncommonly at the back of the neck.

Ulceration of the palate often occurs, and the ulcers are generally symmetrically disposed on both sides of the middle line. Serpiginous ulceration of the tonsils and eruptions around the lips, especially at the angles of the mouth, semi-purulent discharges from the nose or ear, are all commonly seen in the course of the disease. The 'café au lait' complexion, so much dwelt on by various writers, is not in the author's experience of much value in diagnosis; in many cases of well-marked congenital syphilis there is no sign of it, nor is it in any way pathognomonic : the most marked instances of the complexion that he can recall have occurred in infants suffering from chronic intestinal catarrh.

The importance of the facts discussed in relation to the phases of the disease lies in the fact that, in regard to syphilis as a cause of ill-health and failure to thrive, we are dealing with a *remote infection*. The acute disease is one not at all resembling the results of simple malnutrition, and the difficulties of diagnosis occur because the virulence of the disease has been much attenuated. The prognosis in most cases, where the signs do not develop till about two or three months of age, is good, provided that the diagnosis be made and that mercury is given *systematically*. As a rule, the later the manifestation after birth, the better the prognosis. There, however, should be good grounds for the diagnosis of syphilis before the systematic treatment by mercury is undertaken. The following rules represent the author's practice in regard to the matters not directly appertaining to the physical signs of the disease.

But little attention should be paid to the 'history.'

Many infants suffering from primary malnutrition have been systematically treated by mercury because a history of syphilis has been elicited from the father. In not a few of his 'dietetic' cures, the author's chief contribution to the cure of the infants has been his suppression of the mercurial treatment.

If, making allowance for the nature of the disease in infancy, there are no features which can be definitely said to be syphilitic in their character, the disease is probably not present. The idea that apparently anomalous symptoms are to be explained by their being attributed to syphilis shows a want of experience, for the signs of syphilis are not anomalous. Even less attention should be paid to the history when syphilis is not admitted. No weight whatever should be attached to the fact that the previous infants of the parents have been apparently quite free from the disease. The author could quote case after case where the first infant has, as a matter of fact, not suffered from syphilis, while the second infant has. For this there are two reasons. The infection may have been contracted since the first pregnancy. This, however, is not the common explanation. The real explanation in the majority of cases is as follows: The father, prior to marriage, knowing something of the dangers, consults his surgeon, who recommends a mild course of mercury both before and after marriage, and explains the need for systematically taking the doses. The husband religiously carries this out, and, when the infant is born, is relieved to find that no signs of the disease are exhibited by the infant. He then concludes that he is quite free from the disease, and that the possibility of its transmission to his children is now settled. Hence he takes no more mercury. In consequence, it is quite commonly the second infant that manifests the syphilitic taint. As a rule, however, in these cases the prognosis is good. If the author had attended to his own rules, he would

not have made the mistake he did in the following case :

D. F. (R. 1083.) Female infant admitted to the Infants Hospital at the age of six weeks. From the first week after birth the crying of the infant was almost ceaseless. It was vomiting continually ; there was much regurgitation of clear fluid. All kinds of food had been tried without avail. To the medical attendant the author suggested the

Date.	Fat.	Lactose.	Whey Proteins.	Caseinogen.	Whole Proteins.	Feeds per Diem.	Amount in Ounces.	Remarks.
June 20	1·00	5·00	0·50	0·25	—	10	4	
,, 23	1·25	5·50	0·50	0·25	—	10	4	
,, 25	1·50	6·00	0·50	0·25	—	10	4	
,, 27	2·00	6·00	—	—	0·50	10	4	
July 1	1·00	5·00	0·50	0·25	—	10	4	
,, 9	1·25	5·50	0·75	0·25	—	12	4	
,, 11	1·00	5·00	0·50	0·50	—	12	4	
,, 12	1·25	5·50	—	—	0·50	12	4	Peptonized.
,, 16	1·25	6·00	—	—	1·00	12	4	Peptonizing discontinued.
,, 20		5·00						
	1·00		0·50	0·25	—	10	5	
,, 21	0·75	5·50	0·50	0·50	—	10	5	
,, 28	1·00	5·00	0·50	0·50	—	10	5	
,, 31	1·25	6·00	0·75	Nil	—	10	5	
Aug. 6	1·25	6·00	0·50	0·50	—	10	6	
,, 18	1·25	6·00	0·50	0·75	—	10	5	Hyd. c cret. gr. $\frac{1}{3}$ t.d.s
,, 22	1·50	6·00	0·50	0·75	—	10	5	
,, 29	1·75	6·00	0·50	0·75	—	10	5	
Sept. 2	2·00	6·00	0·50	0·50	—	10	4	Hyd. c. cret. gr. $\frac{1}{3}$ every six hours.
,, 8	2·00	6·00	—	—	0·75	10	4	
,, 12	2·00	6·00	—	—	1·00	10	4	
,, 15	2·00	6·00	—	—	1·25	10	4	Hyd. c. cret. gr. $\frac{1}{3}$ plus mercurial inunction.
,, 22	2·00	7·00	—	—	1·50	10	4	
,, 26	1·75	7·00	—	—	1·75	10	4	
Oct. 1	2·00	7·00	—	—	2·00	10	4	

CONGENITAL SYPHILIS. DIET FROM JUNE 20 TO OCTOBER 1, 1909.

diagnosis of syphilis, but, on what appeared to be really reliable evidence, he was persuaded that the diagnosis in this case seemed to be untenable. At the hospital the early treatment was of little avail. Its frenzied crying was so marked when it had been a week or two in the hospital that the author again felt convinced of the specific nature of the illness ; but at this time the infant was suffering from frequent

watery motions, which resisted all treatment, and he hesitated, in its weak condition, to do anything that might increase this. On August 17 there appeared a gumma-like infiltration at the back of the head. Mercury was administered systematically from this period. The diet chart shows the attempts that were made to find a diet for this infant, without success, until mercury was given. The weight chart shows strikingly the result of mercurial treatment, and illustrates the critical importance of diagnosis in reference to the precise cause of malnutrition in infancy.

The points which did not receive sufficient attention were—(1) the crying; (2) the age of the infant; (3) if the vomiting and diarrhœa

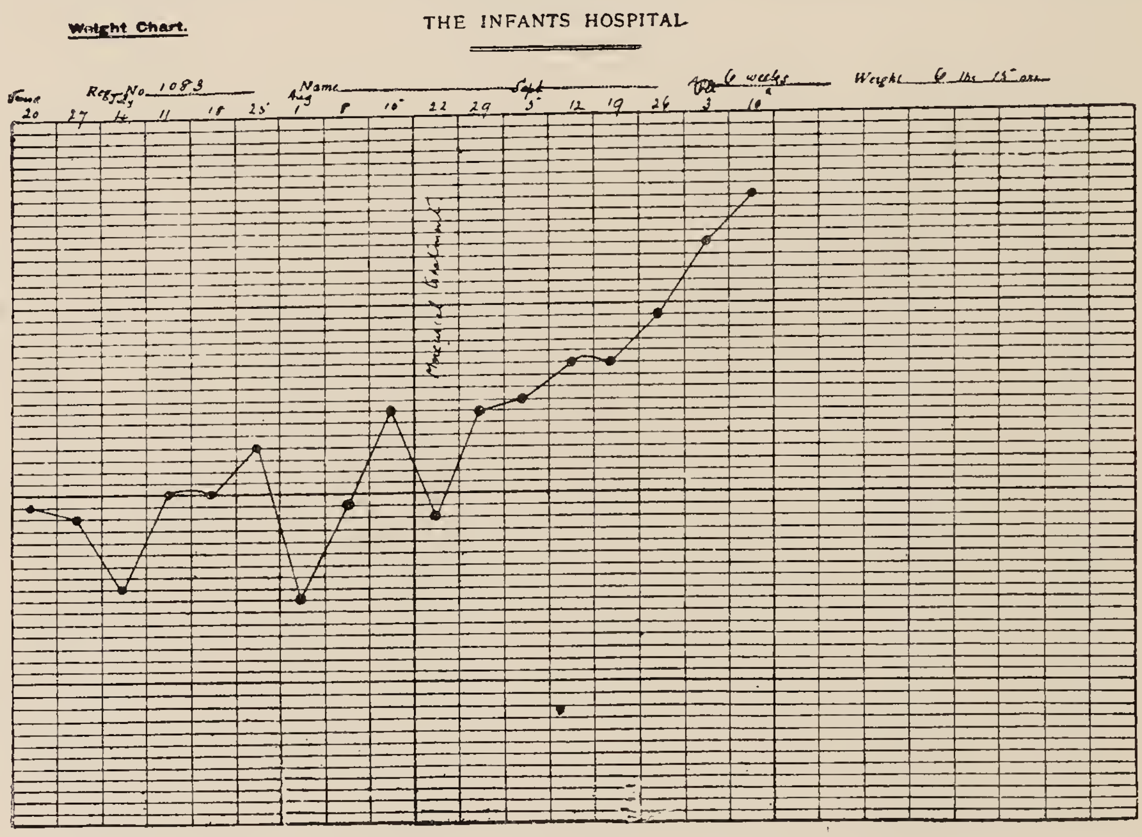

FIG. 50.—CONGENITAL SYPHILIS. WEIGHT CHART.

had been due to dietetic causes the infant should have rapidly progressed.

It may be added that the later history of the infant proved conclusively that it was suffering from congenital syphilis. After being discharged, it was brought back to the hospital in the course of a fortnight with all the typical signs—rash, ulceration, etc. Vigorous mercurial treatment was undertaken. The infant rapidly responded, and when last seen the infant was well and vigorous.

Although congenital defect and congenital syphilis play no part in true infantile atrophy, these two conditions are so liable to be confused with it that the differential

diagnosis is one of practical moment. As a rule the typical cases belonging to the different categories are sharply defined, but in cases where the features are not so clear the accurate differentiation calls for careful and precise analysis of the several factors. In all cases of young infants who are not thriving, the fundamental questions must be answered, or diagnosis and treatment must be in the highest degree empirical and unsatisfactory. In reference to the wasting infant, the critical questions are—

1. Is the failure to thrive associated with the condition of the infant at birth, or has it arisen since birth ?

2. If the condition was present at birth, is it a case of imperfect development—*i.e.*, immaturity—or is it due to specific disease ? If these can be excluded, then the case is one of primary malnutrition.

Atrophy begins in indigestion and malnutrition. In the chapter on Gastric and Intestinal Disorder are narrated the signs and symptoms which, left untreated, finally end in some cases in atrophy. The disease develops slowly, and when well established can only be gradually cured ; for the essential feature of the disease is the atrophy of the digestive structures, as a result of long-continued deprivation of their natural exercise. In all grades of malnutrition the atrophic element is present, but the diagnosis of atrophy is here reserved for those cases in which the loss of function is the distinctive and leading feature. In the worst cases of atrophy death is the usual result. The infant suffering from atrophy presents a pitiable spectacle. The subcutaneous fat has entirely disappeared ; the skin is harsh and dry ; over the forehead it is tightly stretched and very inelastic, while the face is deeply furrowed, so that the crying infant looks like a toothless old man (*vide* Fig. 48). The skin is of a dirty, sallow tinge, and extreme misery is the typical expression. Around the bony structures of the limbs, and especially

of the gluteal regions, the skin hangs in folds, so that the limbs resemble sticks tied round with loose parchment. The infant is often extremely restless, and sleeps badly.

Treatment. — Nothing can be worse for the infant than the administration of a 'good food' — *i.e.*, a food of a composition adapted to the needs of the normal infant. The most fatal mistake in the case of advanced atrophy is to order a wet-nurse. Such a food as would be ordinarily provided by a healthy wet-nurse is utterly beyond the digestive powers of the infant, and is almost certain to produce violent intestinal derangement, with the result that the infant dies from exhaustion. As a rule the infant has been fed for a long period on sterile or cooked foods, the digestive functions have been practically abolished, and the introduction of the infant to a natural food must be conducted with great caution. The fat needs to be very small in proportion; it should very rarely exceed 1 per cent. The lactose may be of the normal amount, or may need to be much reduced, since the normal amount of lactic acid may be too much for the infant, and give rise to diarrhœa. In such a case dextrose may be given, so that the sugar consists of equal parts of dextrose and lactose. It will be found that the dextrose can soon be eliminated, and this should be done as soon as possible, for any gain in weight obtained by means of dextrose is not so satisfactory as that gained on the natural food. The whey proteins should at first be chiefly relied on, owing to the atrophied condition of the mucous membrane. Caseinogen in any but small amounts cannot be tolerated. The casein digestion is, however, as a rule not so severely interfered with as the fat digestion, and even when the infant is making good progress towards recovery, the proportion of fat must be carefully watched. Urgent signs of illness and collapse may follow a sudden increase in the amount of fat in the food. In a case of advanced atrophy, continued progress for a considerable

period is necessary to justify a really favourable prognosis as to the final outcome. Relapse is liable to occur. This usually results from liver and tissue engorgement. In order to deal with the incoming food of which its tissues have been so long deprived, the infant must *grow*, and great care is necessary to see that the infant does not unduly put on weight without increasing in length. The first general signs of improvement are seen in the skin—it becomes less dry and harsh ; the lax tissues of the limbs and the abdomen become firmer, and the subcutaneous tissues begin gradually to reappear. The face then gradually alters and the expression becomes less strained ; the tissues become fuller, and as these changes proceed the infant becomes much quieter and happier. It is when this stage is reached that there is danger. The infant is now digesting its food well, and is gaining in weight, and those in attendance are apt to unduly enrich the food, so that it shall compare more favourably with the food usually given to an infant of its age. The chief danger is fat intoxication (*vide* p. 202). If this condition arises in an infant recovering from atrophy, the result is almost always fatal. In reference to the diet, the *age* should be entirely ignored ; the most important standard is its weight, and even this is misleading if it be not continually remembered that the infant is recovering from severe atrophy.

On August 25, 1909, the author was first consulted in reference to an infant, L. C. (R. 1853), aged thirteen months, weighing 8 pounds, sent to him by Dr. Andrews of Tonbridge. An infant of such a weight as this is generally incurable, and the author gave a very guarded prognosis. The infant was breast-fed for the first three weeks. At three months of age it weighed 11½ pounds. Soon after this it began to waste. Every kind of 'humanized milk' and patent food had been tried, and a wet-nurse had been resorted to without avail.

Date.	Fat.	Lactose.	Whey Proteins.	Caseinogen.	Whole Proteins.	Feeds per Diem.	Amount in Ounces.	Remarks.
Aug. 25	0·75	5·00	0·50	0·10	—	12	3	
,, 26	1·50	6·00	0·75	0·25	—	12	4	
,, 31	0·75	5·00	0·50	0·10	—	12	4	
Sept. 2	1·25	6·00	0·75	0·25	—	12	4	
,, 3	1·00	6·00	0·50	0·10	—	12	4	
,, 11	1·25	6·50	0·50	0·25	—	12	4	
,, 12	0·75	6·00	0·50	0·10	—	12	4	
,, 13		Albumin-water only						
,, 14	0·50	6·00	0·50	0·10	—	6	4	Albumin-water alternately.
,, 16	1·00	6·00	0·50	0·10	—	6	4	Alternately.
	0·50	6·00	0·50	Nil	—	6	4	
,, 18	1·00	6·00	0·50	0·10	—	12	4	
,, 25	0·75	6·00	0·50	0·10	—	12	4	
Oct. 14	1·00	6·00	0·50	0·10	—	7	4	
	0·75	6·00	0·50	0·25	—	6	4	
,, 19	1·00	6·00	0·50	0·25	—	13	4	
,, 21	1·25	6·50	0·50	0·25	—	13	4	
,, 23	0·75	6·50	0·50	0·25	—	13	4	
,, 25	1·00	6·50	0·75	0·25	—	12	4	
,, 28	1·25	6·50	0·75	0·25	—	12	4	
Nov. 4	1·25	6·50	0·75	0·38	—	5	4	Alternately.
	1·50	6·00	0·75	0·25	—	5	4	
,, 6	1·25	6·50	0·75	0·50	—	5	4	Alternately.
	1·75	6·00	0·75	0·25	—	5	4	
,, 11	1·50	6·50	0·75	0·50	—	10	4	
,, 16	1·50	6·50	0·50	0·75	—	10	4	
,, 25	1·50	6·50	—	—	1·00	8	5	
,, 27	1·50	6·50	0·50	0·75	—	8	5	
Dec. 7	1·50	6·50	—	—	1·00	2	5	
	1·00	6·50	0·50	0·75	—	6	5	
,, 9	1·50	6·50	0·50	0·75	—	5	5	
	1·25	6·50	—	—	1·00	3	5	
,, 11	1·50	6·50	0·50	0·75	—	7	6	
,, 18	1·75	6·50	—	—	1·00	7	6	
,, 23	1·75	6·50	—	—	1·25	7	6	
,, 25	1·25	6·50	0·50	0·75	—	7	6	
,, 28	1·00	6·00	0·75	0·50	—	7	6	
Jan. 8	1·25	6·50	0·50	0·75	—	7	6	

ATROPHY. (R. 1853.) DIET FROM AUGUST 25, 1909, TO JANUARY 8, 1910.

The patient was sent to the Infants Hospital, and the preceding detailed account of the treatment illustrates the methods of dietetic adjustment. This case is especially remarkable, as cases of atrophy are generally incurable

when the weight of the infant is less than one-half of the normal weight for age. In this instance the weight was scarcely one-third of the normal.

The next case to be cited is one of a less severe grade of atrophy. The infant (R. 1374) was breast-fed for the first three months, and since then had been fed on con-

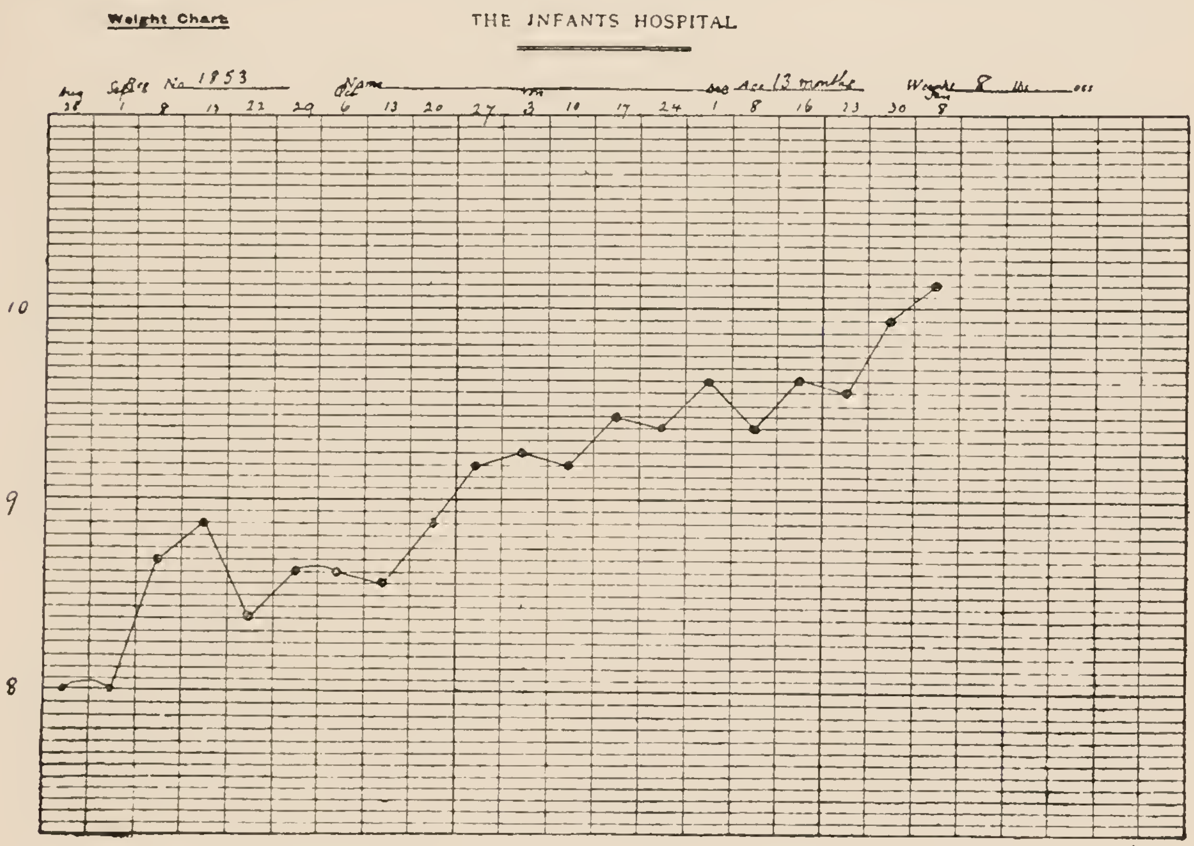

FIG 51.—ATROPHY. (R. 1853.) WEIGHT CHART.

densed milk and water. On admission the infant was four and a half months of age; its weight was 9 pounds 8 ounces. The dejections were grey, offensive, and constipated.

The extremely gradual recovery in the first case as compared with that in the second illustrates the essential feature of the disease. In the first case, such a rapid rise in weight as that shown in the second would probably have led to a fatal result. A serious relapse would have been certain to occur. The successful result in this instance was only achieved by a severe limitation of the diet long after the intestinal reactions had become quite normal.

Date.	Fat.	Lactose.	Whey Proteins.	Caseinogen.	Whole Proteins.	Feeds per Diem.	Amount in Ounces.	
Nov. 24	1·00	5·00	0·75	0·25	--	10	4	Lactic culture ℥iv. per diem.
,, 26	1·25	6·00	0·75	0·25	—	10	4	
Dec. 5	1·50	6·50	0·75	0·50	—	8	5	Lactic culture discontinued.
,, 15	1·75	6·50	—	—	0·75	8	5	
,, 22	1·50	6·50	—	—	0·75	8	5	
,, 24	1·75	5·50	—	—	1·00	8	5	
Jan. 9	1·50	6·50	0·75	0·50	—	8	5	
,, 23	2·00	6·00	—	—	1·00	8	5	
,, 26	0·75	6·00	0·75	Nil	—	8	5	
,, 30	1·50	6·00	0·75	0·50	—	8	5	
Feb. 4	1·75	6·50	0·75	0·50	—	8	6	
,, 9	2·00	6·50	0·75	0·50	—	8	6	
,, 20	2·25	6·50	0·50	0·75	—	7	7	
,, 25	2·50	6·50	0·50	0·75	—	7	7	
Mar. 9	2·50	6·50	0·25	1·00	—	7	7	
,, 16	1·25	6·00	0·50	0·50	—	10	4	
,, 18	1·50	6·50	0·50	0·75	—	8	6	
,, 21	2·00	6·50	0·50	0·75	—	7	7	
,, 23	2·00	6·50	—	—	1·25	7	7	

ATROPHY. (R. 1374.) DIET FROM NOVEMBER 24 TO APRIL 6.

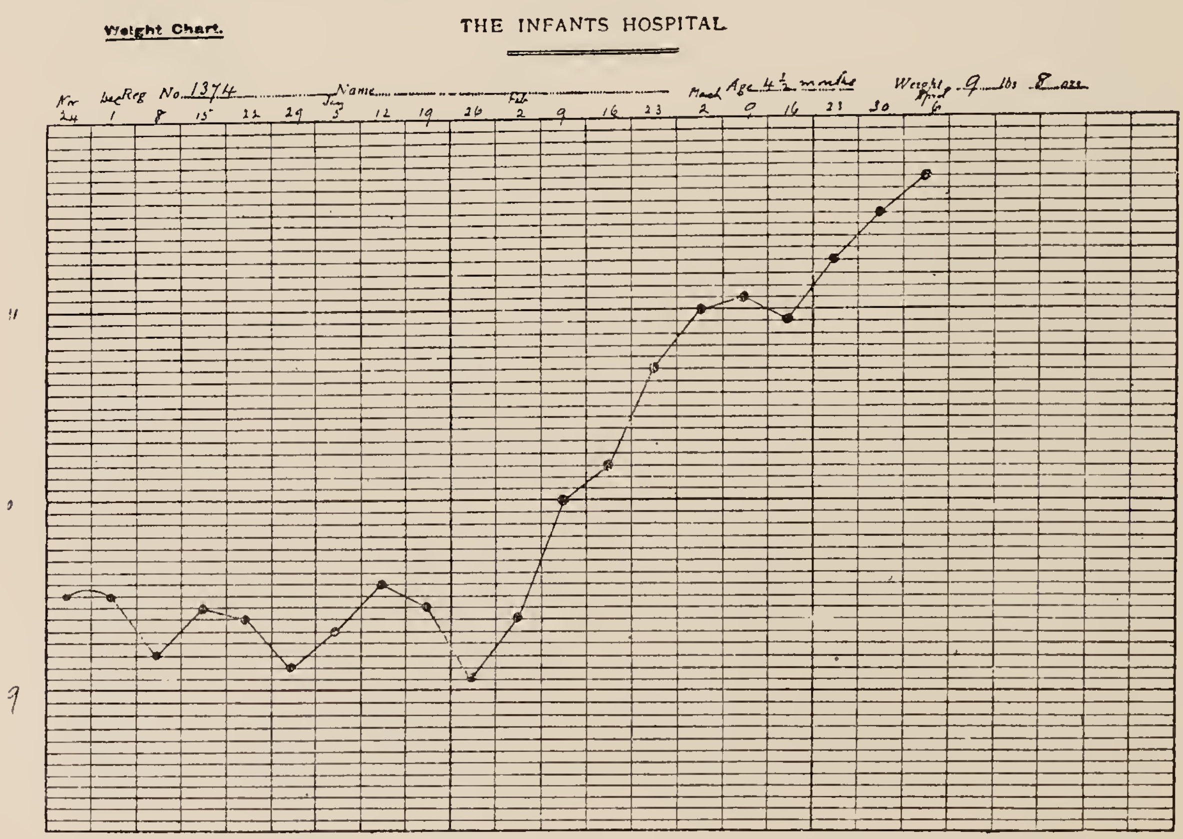

FIG. 52.—ATROPHY. (R. 1374.) WEIGHT CHART.

While the treatment of atrophy is essentially dietetic, the general treatment is extremely important, and but little success will be achieved unless the nursing of the infant is carried out with the most scrupulous attention to detail. The infant must be kept warm; its feet must be wrapped in cotton-wool, and its clothing must be of such a character that, while not heavy or oppressive, it protects the infant from undue loss of heat. The temperature of its room must be warm (63° F.), and, above all, must be equable. The infant in a warm room, with cold air falling on to it from an open window, will soon collapse, much more from absolute chilling of its tissues than from the development of a 'cold.' An incubator should never be used. It is the most effectual method of devitalizing an infant. The number of infants who have lived in an incubator for a fortnight and who have survived for twelve months is very few.

In nearly all cases of atrophy there is serious disturbance of the nervous system, due to malnutrition of the nervous tissues. The infant is continually crying, is persistently unhappy, never smiles, is restless and sleeps very badly. So marked are these symptoms that their early alleviation is urgently needed, for it is unlikely that the infant will profit by the most suitable diet if it does not obtain rest. Potassium bromide in doses of one or two grains, combined with a carminative stimulant, is usually the most effective means of calming the disturbed and restless infant. This drug, however, tends to act as a laxative; where, as not infrequently happens, undue frequency of the dejections is difficult to control, small doses of opium may be most useful, the dose not exceeding 2 minims of the compound tincture of camphor; or the bromide and opium may be combined, for these small doses of opium have but little action as a sedative upon the nervous system.

As a rule, comparatively frequent intestinal dejections are

a good feature in a case of atrophy ; this indicates secretory and peristaltic activity, and the restoration of the chemistry of digestion requires that the intestinal processes should be overactive rather than the reverse. Constipation is always a bad feature, and means that the dietetic adjustment leaves much to be desired. It is also a dangerous symptom, for it greatly increases the danger of fat-intoxication.

CHAPTER XVI

RACHITIS

THE most striking and one of the commonest results of impaired nutrition is the disease generally known by the name of rickets. Though some of its most obvious features are those associated with changes in the osseous system, these are by no means the only effects of the disease. Rachitis is the expression of profound pathological changes occurring in practically all the tissues of the body.[1]

No other disease illustrates so completely the effects of inadequate nutrition. An infant nursed by its mother and receiving from her a sufficient supply of adequate food never contracts the disease, however disadvantageous its environment may be in other respects.

Defect in the diet is the prime and essential cause of rachitis; while, as might be expected, the most advanced forms of the disease are to be seen when the effects of inadequate food are intensified by unhygienic environment.

The characteristic features of the disease are in marked contrast with those of 'atrophy,' for it is essentially a disease of *growth*. If the diet is such that the infant does not grow, none of the clinical manifestations of rachitis

[1] The subject of 'fœtal rickets' is not dealt with, and the author doubts whether any fœtal condition exists to which the term 'rachitis' can be legitimately applied. The condition known as *chondro-dystrophia fœtalis* is probably responsible for the cases described as congenital rickets.

will be seen. The cases of atrophy cited in the previous chapter exhibited no rachitic signs. The diet was so deficient that structural development was not possible. The classical signs of rachitis are only produced when structural development is proceeding, the quality of the structure being pathological because the materials from which it is created are of defective quality.

When the disease is adequately treated at an early stage by the correction of dietetic error, the cure is often rapid and complete. In other cases, where the disease has become well established and the deformity of bone well marked, a real cure is seldom if ever to be attained, though some of the grosser deformities may be, to a certain extent, corrected by surgical operation.

The effects of rachitis on the general constitution are extremely severe. The relationship between the nutrition of the infant and the condition of the child and adult has received but little attention. But there can be no doubt that the defects of nutrition occurring in infancy are of paramount importance in regard to the development of the adult. The cases of retarded physical and mental development in the child and adult are numerous at the present time, and it is probable that one of the chief causes lies in defective nutrition during the period of infancy.

Incidence.—Rachitis is seldom found in breast-fed infants, and the great majority of cases occur among those that are hand-fed. When it arises in a breast-fed infant, it is due to the inadequacy of the milk supplied by the mother, combined, as a rule, with extremely unhealthy environment. Holt points out that in New York it is common, in the case of Italian children, to see marked rickets in those entirely breast-fed. When lactation is prolonged beyond its normal limits, and the infant receives no other, or inadequate, food in addition the disease may arise.

Etiology.—The primary cause of rachitis is the absence of the necessary food elements in the diet of the infant. Bland-Sutton's observations in the Zoological Gardens fully support the conclusions derived from clinical observation in this respect. Lion whelps weaned early and fed solely upon raw meat invariably became extremely rachitic, and the disease was so marked that it was impossible to rear them. Two young bears fed entirely upon rice, biscuits and raw meat developed extreme rachitis and died. Two young monkeys upon an exclusively vegetable diet became rachitic. In the case of the young lions, the hygienic conditions and all the other factors of the environment remained the same, but the food was changed to one consisting of meat, milk, cod-liver-oil, and pounded bones. In three months all signs of rachitis had disappeared.

Effects of Diet.—In regard to the precise elements of the diet the absence of which tends to produce rickets, there can now be little question. At one time, the opinion was widely held that absence of a sufficient quantity of lime was the cause. This is altogether opposed to the facts. Infants who have received a plenitude of lime, as in the case of substitute-fed infants in limestone districts, are by no means protected from rickets. The artificial foods which play the greatest part in the incidence of rachitis usually contain both calcium and phosphoric acid in large quantities.

Deficiency of fat is the most important factor. Deficiency of protein, alone, seldom if ever causes rickets, but when the two are both deficient the disease is much aggravated. This is the explanation of the fact that rickets is so especially liable to occur in hand-fed infants, and occurs most frequently in those fed on artificial foods. Fat is, next to lactose, present in human milk in greater amount than any other of the solid constituents. The artificial foods are characterized, as has already been

shown, by the great deficiency or practical absence of this element. In other cases the necessary food elements may be present in approximately normal amount, but their essential qualities have been either destroyed or seriously impaired by the artificial treatment to which the food has been subjected. This is notably the case with boiled or sterilized milk.

Contributory Causes. — While dietetic error is the prime etiological factor, other factors play a very great part in determining the precise incidence of the disease, the degree of its development, and its effects upon the tissues. Of these contributory causes, defective hygiene is the most prominent. The presence of constitutional disease, such as syphilis, diminishes the resistance of the infant and allows the disease wider scope. Holt refers to the fact that acute diseases of the stomach and intestine are frequently followed by marasmus (atrophy), but only exceptionally by rachitis.

Impure air and the absence of sunlight and invigorating atmosphere are the common incidents of the crowded homes and tenements of the poor classes in the towns. To the infant the plentiful supply of pure fresh air and sunlight are almost as important as its food. Hence the worst cases of rickets are almost always found in the large towns.

The provision of open spaces and of public parks where infants may obtain as far as possible these elements so essential to their health is of great practical importance in relation to the vigour and physique of the population.

Age of Incidence.—The disease is seldom seen before the sixth month or after the third year, while between the tenth and the twentieth months of life most cases occur. Gee[1] analyzed 635 cases in reference to the age of the patients. From twelve to eighteen months there were 183 cases, from six to twelve months 144, from

[1] 'St. Bartholomew's Hospital Reports,' vol. iv., p. 69.

eighteen months to two years 133. Thirty-two cases were seen under six months, and 27 cases were seen in the fourth year. The disease is commonly seen towards the end of the first year, is most frequent in the earlier months of the second year, and seldom occurs after the infant is three years old.

Pathological Changes.—The lesions of rachitis are widespread. They are most manifest in the bones, but they also implicate the brain, liver, spleen, muscles, and, indeed, every organ may be affected to a greater or less extent. The changes in the bones represent a wide deviation from the normal conditions. In the long bones the production of cartilage at the epiphysis is exaggerated, while, along the shaft, there is excessive cellular development beneath the periosteum. The normal formation of the medullary canal by absorption of the inner layers is generally exaggerated, so that the medulla may be much wider than usual.

Morbid Anatomy.—On examining a longitudinal section of a long bone, the lower end is seen to be much enlarged, and the cartilaginous layer between the shaft and the epiphysis is both wider and deeper. This enlarged area constitutes the *blue zone*, and is in marked contrast with the conditions of normal epiphyseal development. A thin regular line normally represents the bone-forming cartilage, whereas in rickets it forms a large and irregular mass. The centres of ossification are soft, swollen and exceptionally vascular; they are surrounded by a mass of degenerate tissue. The outer layers of the diaphyses are thickened and soft; towards the medulla the bone is firmer, and the internal layers are more or less completely ossified. The medulla is hyperæmic, and the medullary contents consist of a soft pink mass somewhat resembling pulpy granulation tissue.[1]

[1] *Vide* Bollinger's 'Pathological Anatomy,' part ii., plate xl., for graphic illustrations of rachitis of the lower end of the femur, and

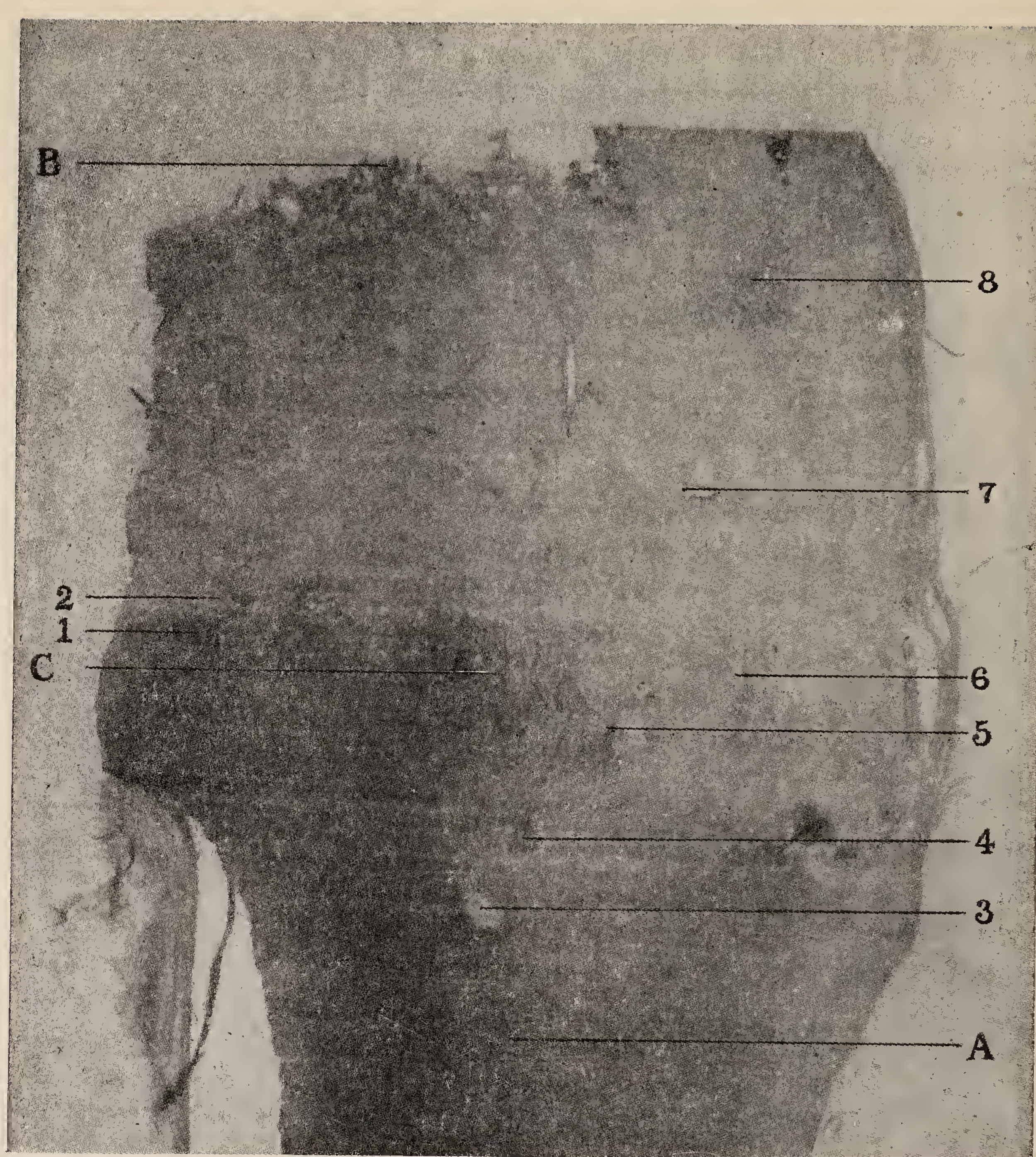

FIG. 53.—DESCRIPTION OF COLOURED PLATE.

Colour-photo-micrograph (× 12) of a double-stained section of a rachitic rib at its junction with the costal cartilage, the osseous tissue being stained orange, the cartilaginous tissue purple. (A) Normal cartilage; (B) Imperfectly formed and uncalcified bone; (C) Proliferating cartilage cells.

At (1) is a line of cells deeply stained in purple. This line represents the normal termination of the cartilage. At (2) is a line of vacuolated tissue. This represents the attempt at actual bone-formation, and the space between (1) and (2) represents the area normally occupied by the tissues in the transition from cartilage to bone. After (2) the bone-formation should be quite definite, and no cartilaginous tissue should be seen; (3) is a medullary space in process of formation, the tinge of orange indicating the beginning of bone-matrix; at (4) this is seen in a more advanced stage; (5) is a proliferating cartilage cell at a stage immediately prior to the formation of bone-matrix, medullary space, and blood-vessel; (6) is a mass of cells of similar character; (7) is a large medullary space in the midst of very imperfect bone; (8) is a mass of cartilage cells. Similar masses are distributed throughout the section between (B) and (C). The light staining is a characteristic feature of rachitic tissue.

Microscopical Appearances.—Microscopical examination demonstrates the precise nature of these gross changes. In the areas of developing bone are masses of imperfectly ossified tissue interspersed between areas chiefly composed of proliferating enlarged cartilage cells (Fig. 54). From the periosteum and medulla are projected masses of similar character, so that the whole bone is composed of osteoid rather than of osseous tissue.

The absorption of calcareous material around the cartilage cells is carried out more or less normally, but the next stage, the formation of bone, is very imperfect. The normal bone is replaced by degenerate cartilaginous and osseous tissue.

After a space of time, varying between six and eighteen months, these degenerative changes cease, and a partial restoration of comparatively normal tissue begins. The cartilaginous masses gradually become hard, and in many cases much harder and denser than normal bone, so as to resemble ivory. The epiphyseal enlargements diminish in size, so that in slight cases the lesions may be obliterated. In advanced cases the results are seen in the shape of numerous deformities.

Clinical Features.—Rachitis frequently occurs in infants presenting superficially the appearance of good health. They are quite plump, and no suspicion that there is anything wrong is entertained by the mother. Indeed, the author has seen a considerable number of infants put forward as fine specimens of babyhood, who on examination proved to be the subjects of rachitis either definitely established or plainly threatening.

The first signs almost invariably occur in the digestive system, and, as they may be observed before any of the classical signs affecting the osseous system are present, this

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rachitis of a rib. These show in colours the naked-eye appearance of the sections.

is pre-eminently the stage for preventive treatment. The typical case may be described as follows: A fat baby about seven or eight months of age. It was breast-fed for the first three or four months. It was then fed on a milk and water mixture with added cream and sugar, the milk being systematically boiled. For about the last month, the infant has been noticed to be not very well. It is fretful, cries a good deal, and the appetite is failing, the infant not caring about its food. On examination the baby is found to be unduly fat, the tissues being rather flabby. The motions are characteristic; they are infrequent, rather solid in character, claylike in consistence and colour, and their odour is offensive owing to the albuminoid decomposition occurring in the alimentary canal. The infant has been loaded with food, often greatly excessive in amount, while as a result of the food being cooked the normal digestive reactions have failed.

Two symptoms are of nearly constant occurrence, and usually appear much earlier than any others—excessive perspiration and restlessness, which are much more marked at night than in the daytime.

The sweating is profuse, so that the head is wet. Upon the forehead large beads of sweat form, and run down over the face. When the infant sleeps the perspiration is extreme. The whole head, face and neck are bathed in moisture, so much so that the pillow is often thoroughly wet and the infant is awakened by reason of its discomfort. The bloodvessels in these cases are usually full, both the veins and arteries being distended. As a result of the excessive sweating, and the consequent irritation, a rash often appears around the hair follicles and on the forehead and neck.

This rachitic sweating is remarkable, as the sweat glands in the rest of the body are not affected to anything approaching the same degree. The skin of the trunk and extremities is often abnormally dry. Of the

PLATE XVII.

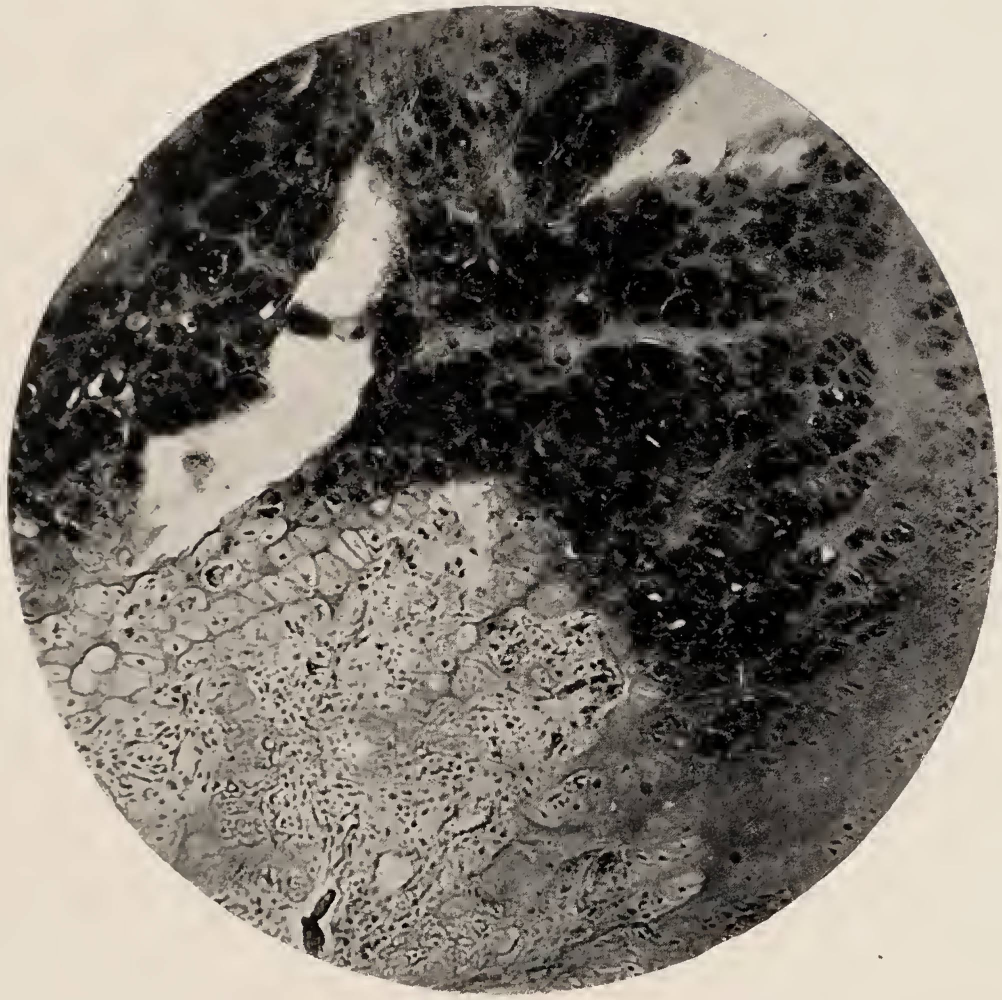

FIG. 54.—SECTION OF RACHITIC RIB (×60), SHOWING THE CHARACTERISTIC PROLIFERATION OF CARTILAGE CELLS AND THE IMPERFECTLY OSSIFIED TISSUE.

To face page 298.

precise cause of this peculiar symptom little is known, but the remarkable localization points to a disorder of the nervous system. Profuse general sweating is a sign of weakness and exhaustion, and in the adult is frequently observed in the convalescence from disease, notably from typhoid fever.

FIG. 55.—'FAT RICKETS.'
I. L., aged three years; quite unable to walk.

The discomfort and restlessness at night are often very marked. The infant throws itself spasmodically from side to side, sometimes lying on its back, sometimes on its face, and changes its position frequently and with great suddenness, as if it had been pushed. While these constant movements are made the infant is not awake, but sleeps on in a disturbed slumber.

Intolerance of the bedclothes is a frequent accompaniment of the restlessness. Regardless of the temperature of the room, the infant will rid itself of all its coverings, kicking away the clothes and lying almost naked on the bed.

As a rule constipation is a prominent feature, and is almost invariably present in the early stages. In the later stages, alternations of constipation and moderate diarrhœa frequently occur. The motions are offensive and frequently contain a large amount of undigested food, sometimes mixed with mucus.

As the disease progresses some emaciation occurs; but in the earlier stages this loss of flesh is unusual, and the

presence of a normal or an abnormal amount of adipose tissue should not be allowed to influence the diagnosis. Excess of fat and lack of muscular tone are, perhaps, the commonest characteristics of early rachitis as presented in infants fed on artificial foods containing a very small quantity of fat and a great excess of carbohydrate.

As a rule, the infant suffers from thirst and the demand for food seems sometimes to be insatiable so that, soon after feeding, the infant is not satisfied until it is fed again. This symptom is probably the result of the systemic need for essential constituents either partially or entirely absent in its diet, and is analogous to the marked predilection shown by scorbutic infants for a diet in which the antiscorbutic elements are freely present.

Frequently, a rachitic infant does not come under observation until the disease has been established for some time and the more profound changes have occurred. In a well-marked case the signs are numerous and extremely characteristic.

The head is large, the chest is narrow, the ribs are 'beaded,' and, at the wrists and ankles, the epiphyses are greatly enlarged. The abdomen is distended and the limbs are curved.

The changes in the bones are widely distributed, and, with the exception of the bones of the skull, are always of the same character, the enlargement occurring at the junction of the bone and the epiphyseal cartilage.

The Skull.—The size of the head is out of proportion to the size of the infant, and the enlargement is due to thickening of the cranial bones and to abnormalities of development. Marked thickening of the frontal and parietal eminences occurs, so that the intervening sagittal, frontal, and coronal sutures appear to be depressed. The

vertex is flattened and the antero-posterior diameter of the skull is increased.

In consequence of the exaggerated depression of the coronal suture, the thickening of the frontal bones and the general flatness of the vertex, the forehead is projected forwards, is of abnormal depth and square-shaped. This large forehead often appears to be larger than it really is, owing to the shape of the head and the contrast with the bones of the face, the growth of which is arrested.

The sutures are as a rule open, and ossification is delayed. The anterior fontanelle, which ought to be practically closed at the end of the first year, may be widely open. The occiput is flattened, and the occipital bone, in contrast with the others, is often much thinned. In some cases the osseous tissue is so deficient that in localized spots the bone is almost as thin as paper, and yields readily to pressure. These spots are always of small size, being either quite minute or about the size of the tip of the little finger. This condition, known as *craniotabes*, is a remarkable feature peculiar to the bones of the skull. It is probably the result of pressure on the ill-nourished bone, from the infant lying with the back of the head on the pillow. In most of these cases the hair in the occipital region is worn away as a result of this pressure and of the frequent and restless movement of the infant during sleep.

The thickening of the bones and the shape of the head are modified under treatment, but in advanced cases some malformation of the head persists throughout life, so that the effects of rachitis in early life may be seen in the adult. The shape of the adult head is notably influenced by the incidence of rachitis in infancy. It is much more noticeable, as a rule, in men, since in women the arrangement of the hair greatly obscures the outlines.

The Thorax.—In the chest, one of the earliest and most

striking of the bone changes is seen in the 'beading' of the ribs. At the junction of the rib and the costal cartilage a nodule is formed; the character of this is precisely the same as that of the epiphyseal enlargements already described in reference to the long bones. These nodules are readily felt on palpation of the chest, but the greater part of the nodule is usually situated on the internal aspect of the chest wall, so that their full extent is to be more clearly realized in the post-mortem room.

Beading of the ribs is an extremely uniform sign, and does not occur in any other disease. Out of 144 successive cases of rachitis examined by Holt, 142 were found to have this sign at the time of the first examination.

Other changes occur in the thorax, due to the softening of the bones and the consequent yielding to atmospheric pressure. The transverse diameter is diminished, and the antero-posterior diameter is increased. At the antero-lateral aspect of the chest on each side is a deep longitudinal depression, extending from the second to the ninth rib, the depression being greatest just external to the junction of the rib and the cartilages. The yielding of the chest wall in this situation leads to the protrusion of the sternum and the costal cartilages, the whole forming the condition known as 'pigeon-breast.'

At the lower part of the chest, extending transversely across it, and corresponding to the line of the diaphragm, a deep furrow, about 2 inches in breadth, is formed, which is known as Harrison's sulcus. In some cases a deep depression is found in the region of the ensiform cartilage, producing the deformity known as the 'funnel chest.'

The Spine.—Deformity of the spine is quite common, but it is only in the most advanced cases that this is due to serious alterations in the structure of the vertebræ. The most common deformity is that of kyphosis, which generally arises from the weakness of the muscles and

ligaments, and disappears when the infant is suspended or the extremities are extended. In bad cases, however, the vertebræ may be affected, and the deformity is not to be corrected by manipulation. Scoliosis and lordosis may also be met with, but are not nearly so frequent as kyphosis. As a rule, the backward curve is not sharp, as in angular curvature, but is gradual. It begins in the dorsal region, is most prominent in the dorso-lumbar, and gradually disappears in the lower lumbar region.

The Clavicle.—The clavicle is, as a rule, not greatly affected, except in severe cases. The disease shows itself in an enlargement of the curve in its inner third, and in thickening of the epiphyses. Occasionally the bone is incompletely fractured ('green stick fracture').

The Extremities.—In the upper extremity, the most frequent abnormality is the enlargement of the epiphyses. This occurs most commonly at the wrist, and is one of the typical signs, being nearly always present. It may also be present at the elbow.

Both the radius and ulna are commonly affected, becoming much curved, the convexity of the curve being on the extensor aspect. Incomplete fracture of these bones is of common occurrence and almost invariably occurs on the concave side of the curvature.

In the lower extremity, the enlargement at the ankles is generally found to correspond with that at the wrists, though, as a rule, it is not so well marked. In advanced cases the upper epiphyses of the tibia and fibula are affected. Both these bones may be much bent, the tibia usually being the more severely affected. The femur may show some curvature forwards and outwards, and its condyles are enlarged.

When the disease has progressed the deformities of bow-legs and knock-knees are seen, but these do not usually manifest themselves till infancy is passed.

The Pelvis.—The pelvis in severe cases may be ex-

tremely distorted, and in the female adult this is of serious moment in reference to obstetrical considerations. With the exception of the pelvis of mollities ossium and some other rare forms, rachitis is responsible for the worst cases of pelvic contraction. In regard to the number of cases, this disease is overwhelmingly in preponderance.

Holt refers to an important fact which has received little attention. The growth of the long bones is arrested. This is one of the most characteristic features, so much so that a rachitic child of three years often measures, in height, 6 or 8 inches less than a healthy child of the same age, the difference being almost entirely in the lower extremities. The arrest of growth is also seen in the bones of the face, especially the upper jaw and the malar bones. The lower jaw alters in shape, so that, anteriorly, it is flattened, and the angle is much more acute than is normally the case.

The bone changes in rickets are therefore of wide extent and affect the whole skeleton. Attention is naturally drawn to these features, since they present such obvious abnormalities as to be quite apparent to the untrained observer. The changes affecting the other tissues are no less severe, but the fact and character of these lesions are not so clearly recognizable.

The Muscles and Ligaments.—The muscles are very poorly developed, so that their power is much less than normal, and in some cases is almost absent. The inability of infants to maintain themselves in an erect posture, to sit up, or to walk, is not so much due to the bone changes as to the absence of muscular strength.

The ligaments and especially those structures of a ligamento-muscular type connected with the important joints, the spinal column and the neck are relaxed and atonic. The ligamental laxity and the muscular weakness give rise to a flail-like mobility of the limbs which

is in marked contrast to the normal muscular tone and posture.

Of this atonic condition a notable example is the extreme distension of the abdomen which is so frequently present. The muscles of the abdominal wall and of the intestines are relaxed, with the result of extensive dilatation of the whole intestinal tract. The abdomen is tympanitic and tense.

In the final stages of the disease, when a fatal result is not unlikely to ensue, emaciation occurs. The facial expression becomes senile and the infant is apathetic. Respiration is laboured and quick, owing to the weakness of the respiratory muscles and the thoracic deformities.

There is usually some tenderness in the neighbourhood of the joints when the disease is active, but it is never acute and is frequently absent. The acute tenderness such as is found in scorbutus is never present in an uncomplicated case of rachitis.

In a disease associated with so many complications, febrile symptoms frequently appear and disappear; but *pyrexia* is not an essential sign of rachitis, and most rachitic changes develop without fever. Such rises of temperature as do occur are generally associated with intestinal toxæmia.

During the most progressive stage enlargement of the spleen almost invariably occurs, but this seldom persists and is never very great. Enlargement of the liver also occurs, though the increase is not as great as that occurring in the spleen, and it is not so frequent. An important point in determining the size of the liver and spleen should always receive due recognition. Owing to the deformities of the thorax, both these organs are pushed downwards, so that they become more prominently abdominal organs; and in the estimation of the size of these organs the part played by this downward displacement must be allowed for.

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Dentition.—The process of dentition is generally delayed and may be complicated by severe nervous or intestinal symptoms. In some cases the first teeth appear at about the normal time, while the appearance of the others is irregular and delayed. Dental caries is a common incident.

Ultimate Effects of Rachitis.—Rachitis is a disease attended with a high mortality with which it is never credited, for the disease itself is seldom, if ever, fatal. In consequence of the cachectic condition and the extreme debility associated with advanced rachitis, the specific infectious diseases, such as measles, pertussis, and others, are associated with a much higher mortality in these cases than in others. Associated more or less closely with rachitis is a large class of disorders, such as bronchitis, diarrhœa, laryngismus stridulus, and convulsions; these are attended with many fatal issues.

The figures given by Gee[1] support this statement. Out of 50 cases of laryngismus stridulus, 48 were rachitic, and of those 19 had convulsions. Of 102 cases of general convulsions, 46 were rachitic.

Even in later life the effects of rachitis seem unquestionable. Gowers found that 10 per cent. of epileptics had suffered from rachitis. Coutts found the rachitic history more frequent, and assessed it at 17 per cent

These degenerations of the nervous system must be a prominent factor in the want of resistance to disease, while in the cases of the numerous lung complications the effects are greatly enhanced by the chest deformities already referred to.

Treatment.—The active stage of rachitis is of comparatively limited duration. Treatment begun late in the second year must be of little avail, for probably by this time irremediable mischief has been done. At the

twentieth month of life the active disease is rarely seen. At about this time the cessation of the disease almost always occurs, owing to the changes in the diet and environment. Hence diagnosis and treatment should be especially devoted to the recognition and correction of the defects when the bone changes are not present, or are so comparatively slight that they can only be detected on careful examination. In such cases due adjustment of the diet and environment is attended with most satisfactory results.

Under the present conditions, the majority of cases are not presented for treatment until the disease has been in existence for a considerable period and where its results are apparent on the most superficial examination.

In the treatment of these cases, drugs are often temporarily required for the various intestinal, nervous, and other complications. But in regard to the disease itself drugs are of no avail. Phosphorus, iron, arsenic, may be of use in regard to certain of the incidents of rachitis, but they are useless in regard to the specific disease. The various preparations containing lime salts, advocated from theoretical considerations based on the deficiency of lime in rachitic bone, are quite useless.

The two factors of the utmost importance are the diet and the character of the environment in regard to hygienic conditions.

Fresh air and plenty of sunlight are essential. Whenever it is possible, the infant should be in a climate mild and warm, so that the infant can be out of doors for a great part of the day. The bracing and more vigorous climates are scarcely suitable, as these patients are extremely susceptible to cold. Later, when the infant has become more vigorous and its powers of resistance have increased, a more bracing air is of great advantage.

The dietetic treatment is extremely important. The common error is to overfeed the infant. As a result of

the improper feeding, the digestive system is in a pathological condition, and the food must be dilute until this is remedied.

In most cases the motions are offensive, clearly indicating putrefactive decomposition of the albuminoids, resulting from the continued administration of boiled milk.

The anti-proteolytic properties of raw milk may be sufficient to correct these abnormalities ; but it is advisable that a bacteriological examination of the dejections should be made, so that the intestinal conditions may be accurately appraised. In these cases the author's general rule is, having made the bacteriological diagnosis, to carefully note the changes occurring in the intestinal flora. If these proceed satisfactorily, then no other treatment may be necessary. In many cases, however, raw milk is not powerful enough, and the reverse process is seen, the anti-proteolytic organisms being overcome by the dominant proteolytic bacteria. In such cases the administration of pure cultures of organisms specifically trained against the proteolytic organisms is clearly indicated.

In many cases of rachitis it is essential to the effectual cure of the disease that a loss of weight should occur. An infant of seven or eight months of age, weighing some 18 pounds, may lose 1 pound with advantage. The tissues are unhealthy, the structure is abundant, but poor in character, and the early rachitic features may be obliterated by throwing the infant upon its own tissues. For the rachitic structure is but feebly organized, and active oxidation will result in its depletion and removal.

Bronchitis and broncho-pneumonia are extremely liable to occur in rachitic infants, and in a case where the disease has been established for some time the high

temperature associated with broncho-pneumonia is of great ultimate benefit to the infant, since it accelerates the removal of unhealthy tissue.

(R. 1950.) The weight chart on p. 306 is that of L. F., admitted to the Infants Hospital, aged sixteen months; weighing 17 pounds 1 ounce. Rachitis was well marked. The head, the chest, and the limbs, all clearly manifested the well-known features. The sweating was so excessive that the infant's clothing had constantly to be changed, all the garments being soaked. The infant was suffering

Date.	Fat.	Lactose.	Whey Proteins.	Caseinogen.	Whole Proteins.	Feeds per Diem.	Amount in Ounces.
Oct. 3	1·25	6·00	0·50	0·25	—	12	3
" 7	—	—	—	—	—	12	4
" 12	1·50	6·00	0·50	0·50	—	8	5
" 14	2·00	6·00	0·50	0·75	—	8	5
" 19	2·50	6·00	0·50	0·75	—	8	6
" 26	2·75	6·00	0·50	0·75	—	7	6
" 28	1·50	6·00	0·50	0·25	—	12	4
Nov. 2	2·00	6·00	0·50	0·50	—	10	4
" 4	2·00	6·00	0·50	0·75	—	10	4
" 6	2·50	6·00	—	—	1·00	8	5
" 9	3·00	6·00	—	—	1·25	8	6
" 16	3·00	6·00	—	—	1·50	7	7
" 18	3·25	6·00	—	—	1·75	7	7
" 27	3·25	6·00	—	—	2·00	7	7
Dec. 7	2·75	6·00	—	—	2·25	7	7
" 16	3·00	6·00	—	—	2·50	7	7
" 21	3·00	6·00	—	—	2·75	7	7

RACHITIS. (R. 1950.) DIET CHART FROM OCTOBER 3 TO DECEMBER 30.

from a severe attack of broncho-pneumonia, and a fatal issue at first appeared imminent.

As a result of the acute disease, the loss of weight was rapid, and was an exaggeration of what should normally occur in an uncomplicated case. Nevertheless the weight chart, as shown in Fig. 56, affords a

concrete illustration of the essential features in the cure of a case where the structural defects have proceeded to a considerable extent. The dietetic treatment is shown in the chart on p. 305.

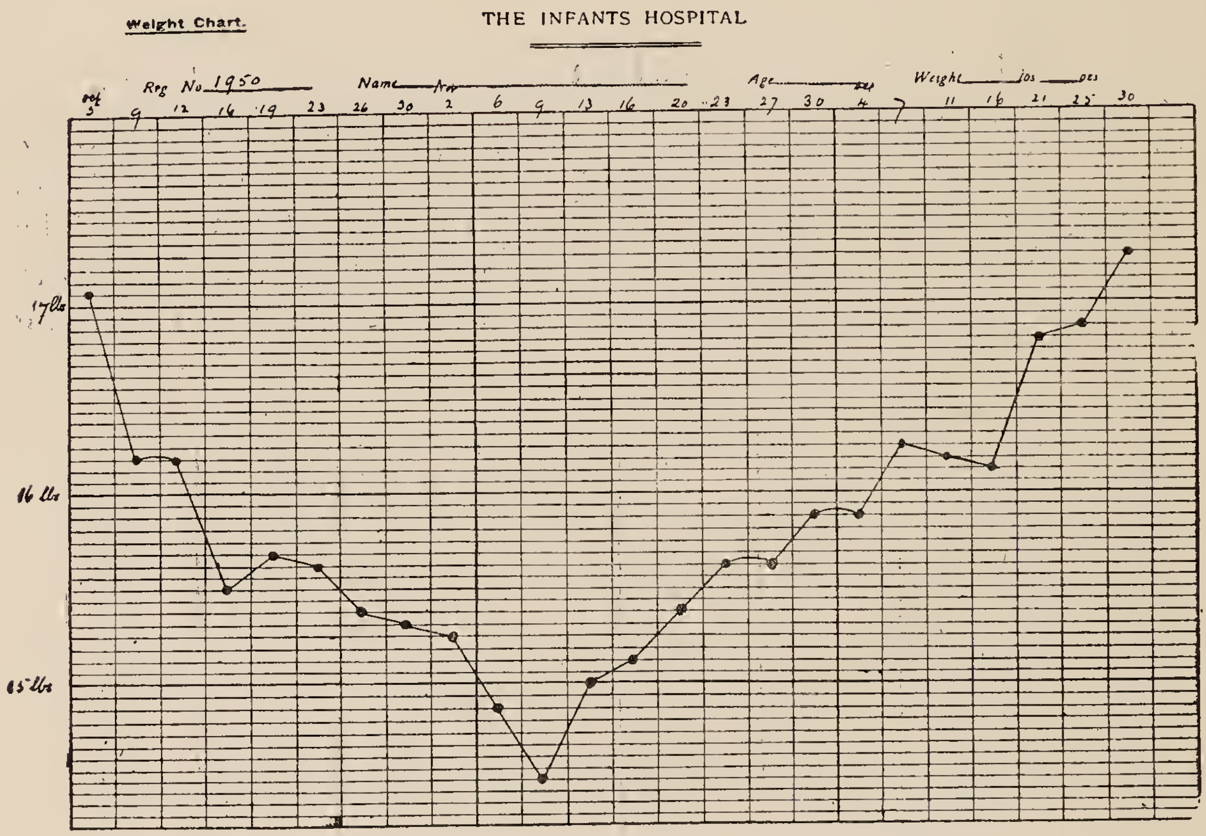

FIG. 56.—RACHITIS. (R. 1950.) WEIGHT CHART.

In any acute disease in an infant loss of weight rapidly occurs; it is an unfortunate concomitant of the disease which cannot be avoided. In rachitis, where the disease has progressed to the extent of affecting the bodily structure, it is an essential preliminary to the effective cure of the disease. For healthy structure cannot be laid down until the rachitic tissue—pathological in character and excessive in amount—has been eliminated. A practical point connected with the pathology of rachitis well illustrates the essential condition of the rachitic infant.

In the course of the author's lectures at the Infants Hospital, two sections are projected upon the screen by means of the Epidiascope, illustrating (1) the normal bone formation at the epiphyses; (2) the bone-forming tissue at

the epiphyses in rachitis. The first section occupies the centre of the screen, and the definite layers of cartilage, bone-forming zone, and bone, are clearly defined. The three layers are clearly seen and occupy but a small space, so that the relation of each layer to the others can be readily recognized. The demonstration of the section illustrating the rachitic processes, so as to compare it with the preceding section, is attended with certain practical difficulties. If the same power is used, the three layers are not seen at all; only a small portion of one layer is seen on the screen, for the bulk of the tissue is so great that one layer of the diseased tissue occupies much more room than the three layers of the normal tissue. In order to bring the whole section within the microscopic field a much lower power has to be used. When this image is projected, a remarkable change is seen, for, despite the great reduction in magnification, the whole screen is occupied; the vacuolated spongy tissue is seen spreading itself everywhere. In length the section is enormously greater, while the increase in breadth is strikingly shown by the bulging of the diseased tissues in the line of least resistance. Those who have witnessed this demonstration have little difficulty in understanding that the removal of this tissue is the first essential to a cure of the disease.

To effect this physiological change in bodily structure, every advantage must be taken of the natural physiological processes. Growth for the time must be stopped; only sufficient food must be administered to maintain the normal functions and to satisfy hunger. Both fat and proteins need to be reduced much below the normal standard; the sugar should be small in amount. Starch in any form should be absolutely withheld. No other food but milk should be given, but the infant may receive plenty of water.

Date.	Fat.	Lactose.	Whey Proteins.	Caseinogen.	Whole Proteins.	Feeds per Diem.	Amount in Ounces.
June 29	1·50	6·00	0·50	0·25	—	10	4
July 8	1·75	5·00	0·25	0·50	—	10	4
„ 13	2·00	5·00	0·25	0·75	—	8	5
„ 17	2·00	5·00	—	—	1·25	8	5
„ 24	2·25	5·50	—	—	1·25	8	5
Aug. 3	2·50	6·00	—	—	1·50	7	6
„ 7	2·75	6·00	—	—	1·75	7	6½
„ 17	3·00	6·00	—	—	1·75	7	7
„ 21	3·25	6·00	—	—	1·50	7	7
„ 24	3·25	6·00	0·25	0·75	—	7	7
„ 26	2·50	6·00	0·25	0·75	—	7	7
Sept. 7	2·50	6·00	—	—	1·00	7	7
„ 23	2·50	6·00	—	—	1·50	7	7
„ 28	2·50	6·00	—	—	1·75	7	7
Oct. 5	2·75	6·00	—	—	1·75	7	7
„ 14	2·75	6·00	—	—	2·00	7	7

RACHITIS WITH COMPLICATIONS. (R. 1764.) DIET FROM JUNE 29 TO OCTOBER 19.

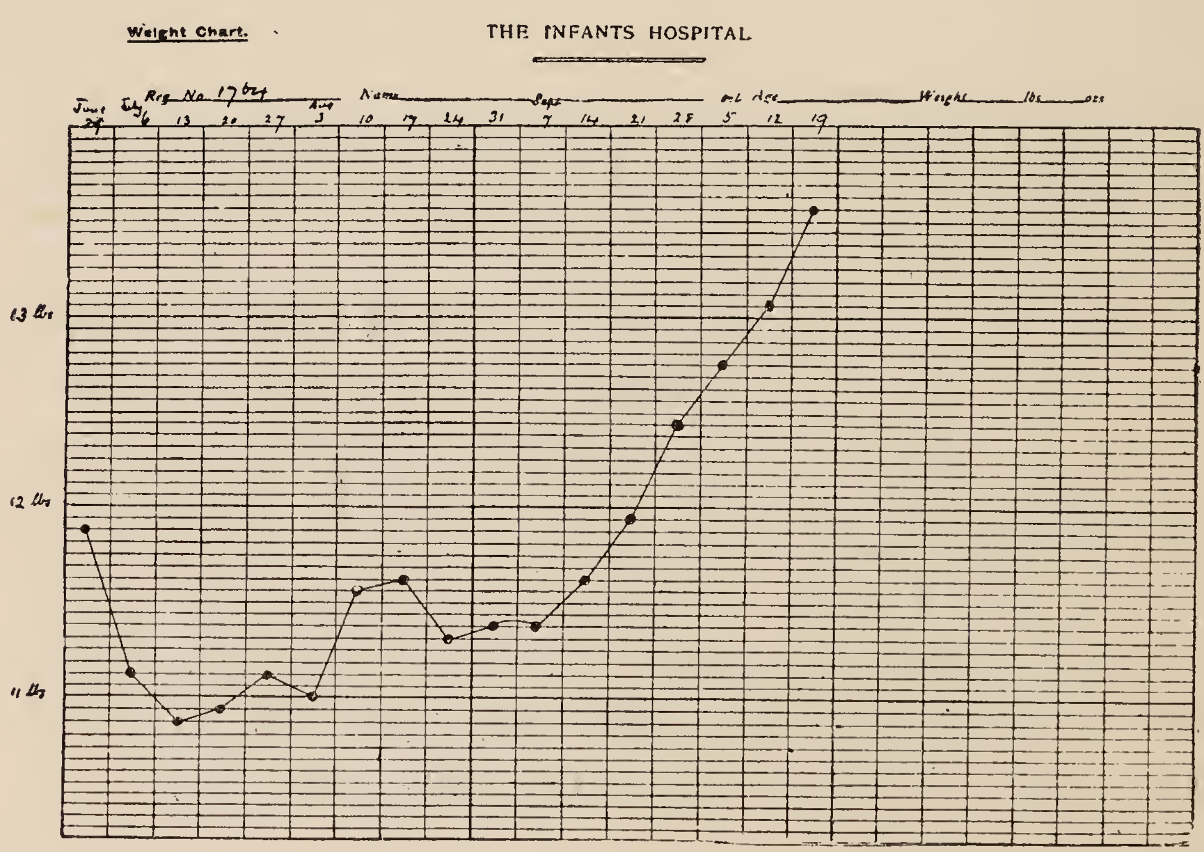

FIG. 57.—RACHITIS. (R. 1764.) WEIGHT CHART.

The following case shows rachitis and its complications occurring in an infant much younger than the infant previously cited, and the recovery and dietetic adjustments are of interest in illustrating, comparatively, the conditions.

E. C. (R. 1764), aged eight months, weighing 11 pounds 14 ounces. Breast-fed for the first six months, for the last two months fed on milk and water. The infant on admission was suffering from rachitis, gastritis, enteritis, otitis, convulsions, and bronchitis. Lateral nystagmus was present. The head was constantly held towards the right. On the head being pressed to the left the nystagmus increased. All the signs and symptoms yielded comparatively rapidly to treatment.

Many of the symptoms of restlessness, want of appetite, and fretfulness rapidly disappear as a result of the dietetic adjustment to the infant's physiological needs. The milk must be fresh, not boiled or cooked in any way. Gradually the fat and proteins may be raised to the normal, the chief indication being the character of the dejections. The dejections should be free, semi-liquid, inoffensive, and not containing undigested material. Infrequent and solid dejections are a bad sign, since they show that the chemistry of digestion is inactive.

When the infant has recovered from alimentary disorders, it may be placed on a more varied diet. But while disorder is present it is of the greatest importance that the primal proximate principles should be made use of, to the exclusion of more complex foods. By this restriction of the diet it is possible to control the nutrition and to know the facts of the case in a manner that is impossible when the diet is composed of a large variety of foods.

Hygienic Management.—Especial care must be taken to insure that the body-heat is maintained. The maintenance of equilibrium in this respect is one of the greatest factors in regard to the health of the infant, and one which is very widely neglected. In order to reserve as

much of the fat as possible for direct nutrition, it is important that this energy should not be wasted in correcting excessive loss of heat.

The abdomen should be protected by a closely-fitting flannel bandage, which serves to keep the infant warm, and at the same time to provide the support which a rachitic infant generally requires.

The living and sleeping rooms should be maintained at an equable temperature of 63° F., and the ventilation should be so arranged as to provide for the ingress of plenty of pure air and the egress of impure air without draughts.

It is frequently found that ventilation is deficient owing to the absence of sufficient provision for the regular egress of impure air; without this the air of the room must necessarily be impure.

The extremities need to be protected so that these are warm. 'Cold feet' are found here as in other conditions, and the feet and legs should therefore be well protected by means of stockings.

Special provisions need to be made to counteract the disturbance of the bed-clothes and the exposure of the infant resulting from its restlessness at night. The infant should be placed in a flannel sack tied just below the shoulders; over this a flannel nightgown with long sleeves should be worn, buttoning at the wrists and neck, and lightly fastened to the sack at the feet. In this way the infant may be securely protected. Weighty bed-clothes are especially resented by the rachitic infant; they should be warm but light, the greater reliance being placed on the night garments of the kind described.

The attendants of the infant should always be cautioned in regard to the condition of the bed-clothing and the night garments. They must be dry. This object is often difficult of attainment without constant care, in consequence of the copious sweating, so that the ordinary

'airing' of the clothing is not sufficient. They require in these cases to be dried by direct heat.

Treatment of Complications.—For the profuse sweating of the head and neck, belladonna or its alkaloid, atropine, may be given. Three minims of tinctura belladonnæ should be given in the afternoon, and 5 minims on the infant being put to bed; or $\frac{1}{600}$ grain of atropine may be given in the afternoon, and $\frac{1}{400}$ grain at bedtime—these doses for an infant of six months.

Infants are sometimes extremely tolerant of belladonna, and it may be necessary to increase the dose. This should be done with caution, as in some cases the usual tolerance is not shown. Small doses of bromide of potassium are useful in allaying the restlessness and conducing to undisturbed sleep.

Bronchial catarrh is liable to appear, and, if neglected, is prone to end in broncho-pneumonia, which is always a serious complication in consequence of the thoracic deformities.

On the occurrence of symptoms of bronchitis, the infant should be given a hot bath, and after rapid drying with warm towels the chest should be well rubbed with a liniment, such as the linimentum camphoræ ammoniatum; this acts as a stimulant, and its inhaled vapour incites the expulsion of mucous exudation.

Chloretone inhalant provides a valuable means of checking the extension of catarrh. This preparation consists of a mixture of chloretone, camphor, menthol, and oil of cinnamon, mixed with a basis of petroleum. It should be sprayed into the throat by means of an atomizer.

When the symptoms are severe and dyspnœic distress is evident, vinum ipecacuanhæ should be given to produce vomiting, and thus assist the expulsion of the mucous secretion blocking the bronchial tubes. Unless the mucous secretion is freely evacuated, its interference with respiration is severe. For systematic administration the

drug may be given as in the following prescription for an infant of six months of age:

℞	Vini ipecacuanhæ - - -	♏iii.
	Liq. ammon. acet. - - -	♏x.
	Aquam - - - - -	ad ℥i.

In all such cases, alcohol in the form of brandy is of great value.

A steam-kettle is of great service whenever the cough is harsh and irritating. The steam should be allowed to issue from the kettle near the bed; a steam-tent is never necessary and generally harmful. In cases where the respiration is laboured and the infant is dusky or cyanosed, oxygen is invaluable. At the Infants Hospital, where severe broncho-pneumonia in rachitic infants is a common experience, steam, oxygen, and ipecacuanha, are the therapeutic agents chiefly employed.

The affections of the nervous system in the shape of laryngismus stridulus and of convulsions are frequent complications. An infant suffering from convulsions should be placed in a hot bath (from 100° F. to 105° F.), and amyl nitrite should be given as an inhalation. After a considerable experience with chloroform and other drugs, the author has found amyl nitrite the most satisfactory. In most cases the convulsions cease almost immediately after its inhalation.

To prevent the recurrence of convulsions, bromide of potassium should be given. The first dose should consist of 2 grains, and this should be followed by 1 grain every hour for the following six hours. In cases where convulsions recur, opium or morphia is the most efficient means of combating the attacks.

Numerous observers with great experience are agreed that the tolerance of morphia in cases of convulsions is well marked, and a weak action of the heart is not a contra-indication to its use. 'Objections are urged against it only by those who have had no experience with its use'

(Holt). For an infant of six months old, $\frac{1}{50}$ grain should be injected hypodermically. Or, instead of the hypodermic injection of morphine, 4 grains of chloral hydrate may be administered *per rectum* for an infant of the same age. But morphia is more certain. When convulsions are due to the venous condition of the arterial blood, the administration of oxygen is attended with beneficial results.

Laryngismus stridulus is an alarming complication, and in some cases it may be quickly fatal. In the majority of cases, however, the first attacks are comparatively mild, and the attacks gradually increase in severity. When the nature of the attacks is diagnosed at an early stage and the case is suitably treated, a fatal result is very rare.

The onset is sudden: the head is thrown back; the face becomes at first pale, then deeply cyanosed; respiration ceases. For a few moments the infant is in the greatest distress; the cyanosis deepens, till the infant is almost black and violent, but abortive attempts at respiration are made. After this condition has lasted for some seconds, the spasm ceases and a peculiarly long and deep inspiration follows. As a rule, the incidence of the attack is determined by some excitement—by crying or by a fit of anger.

The face should be sprinkled with cold water and the tongue should be drawn well forward, and smelling-salts should be held at the nostrils. As a rule this rapidly ends the spasm. When, however, the attacks recur at frequent intervals, chloroform should be administered. The infant should then be kept very quiet, should not be disturbed by visitors, and potassium bromide may be given with advantage for a few days.

The presence of digestive disorder, of constipation, of scybalous masses in the rectum, are some of the frequent and immediate associations of laryngismus, and these conditions need to be dealt with. In some cases local

diseases of the air-passages may either be the cause or the aggravation of the disorder. Of these, adenoid vegetations and hypertrophy of the tonsils or uvula are instances.

In regard to the nervous system, the best results will be obtained by adequate diet. The improvement in the functions of the nervous system as a result of suitable food is most striking, and is often to be seen in less than a fortnight from the beginning of treatment.

CHAPTER XVII

SCORBUTUS

SCORBUTUS, as it occurs in infants, is characterized by its dependence on imperfect nutrition. The disease is almost entirely confined to a certain period of infancy. It rarely arises before six months or after eighteen months of age, and is most commonly seen in the latter half of the first year, especially during the eighth, ninth, and tenth months. In rare cases, however, it may be found much earlier, and Holt refers to cases in which the disease has been observed in infants less than one month old. The author has seen two cases in infants three months of age.[1]

In a mild form it characteristically occurs in infants who have not suffered previously from any serious disease, and who have been under the most favourable conditions in regard to general care and environment.

The disease as seen in infants was first described by Cheadle in 1878.[2] Prior to this, Smith had in 1876 described a case, but its nature had not been recognized.[3] Gee in 1881 included a series of cases of the same disease in an article entitled 'Osteal or Periosteal Cachexia.[4] In

[1] *Vide* p. 324.

[2] 'Three Cases of Scurvy supervening on Rickets in Young Children.'

[3] 'Hæmorrhagic Periostitis . . . with Separation of the Epiphyses' ('Transactions Pathological Society, London,' vol. xxvii.).

[4] 'St. Bartholomew's Hospital Reports,' 1881.

1883 Barlow[1] demonstrated the clinical and pathological character of the disease. The conclusions at which he arrived have been fully confirmed by later observations.

Etiology.—Practically all observers are agreed that the disease is entirely due to defective diet, though the precise nature of the defect has never yet been fully demonstrated. Certain facts, however, are clearly established. So long as the food is fresh it never produces scurvy. Fresh food possesses some property—the antiscorbutic property—which is destroyed at a high temperature.

Some writers have suggested that the disease is due to a micro-organism—a suggestion which is, however, based on little, if any, evidence. The theory of bacterial etiology as the primary element is highly improbable by reason both of the incidence of the disease and its disappearance.

Gee[2] inclined to the view that the disease is due to a poison of the nature of a ptomaine, though admitting that nothing is certain in regard to this.

The evidence that scorbutus is primarily due to the *absence* of some necessary element, and not to the presence of any poisonous products, is extremely strong; though it may be that these products arise as a result of the defective metabolism. These, however, must be regarded as effect rather than cause. The facts of the disease all point in this direction.

The infants are generally healthy in other respects, and the disease is gradual in its onset—both of which facts are against its association with ptomaine-poisoning as this term is usually understood. And, despite the maintenance of the same diet, the disease is to be cured provided that the antiscorbutic element be added in sufficient amount.

Moreover, food that produces scorbutus only produces

[1] 'On Cases described as Acute Rickets . . .' ('Transactions Royal Medico-Chirurgical Society,' vol. lxvi.).

[2] *St. Bartholomew's Hospital Journal*, June, 1903.

it when this diet is either the sole diet or is so much in excess that the other food is practically negligible. Condensed milk never produces scorbutus when it is only part of the dietary, and the other food is antiscorbutic in character and is sufficiently plentiful.

The valuable investigations of the American Pediatric Society carried out in 1898 afford the most complete illustration of the subject. The records of cases were collected, and the statistics in relation to the diet leave no room for doubt as to the essential cause of scorbutus. The figures are as follows:

PREVIOUS DIET OF INFANTS SUFFERING FROM SCORBUTUS.

Breast milk was accountable for - - - -	10	cases.
Breast milk with additional food was accountable for - - - - - - - - -	2	"
Raw cow's milk was accountable for - - -	5	"
Pasteurized cow's milk was accountable for -	20	"
Condensed cow's milk was accountable for -	60	"
Sterilized cow's milk was accountable for - -	107	"
Proprietary foods were accountable for - -	214	"

In reference to those cases occurring in breast-fed infants, no case appears to have ever been recorded where the milk, as judged by the progress of the infant and by analysis, has been at all of normal standard. It is probable that, not only were the milks altogether abnormal, but that all the mothers were in a state of comparative starvation. In regard to this, it is noteworthy that on raw cow's milk only five cases are recorded. In the chapter dealing with the effects of heat on milk, the important factors have already been discussed, and it is only necessary here to draw attention to the striking demonstration of the part played by condensed milk, sterilized milk, and proprietary infant foods. Speaking of condensed milk and of other artificial foods in relation to scorbutus, Gee says: 'These foods came in about the year 1870. I was then at the Children's Hospital, and previous to that time I had never seen a case. When

I first saw it and described it, I thought it a new disease.'

Pathological Changes.—The pathological changes in advanced scorbutus are characteristic. Hæmorrhage into the tissues is the prominent lesion. It may be found in the muscles, in the tissues, in the neighbourhood of the joints, and occasionally, though rarely, in the joints themselves. Hæmorrhages of variable extent occur in the serous cavities such as the pleura and pericardium, and into organs such as the liver and spleen. But by far the most constant and most striking feature of advanced scorbutus is subperiosteal hæmorrhage. This is chiefly found in connection with the long bones, and most markedly in connection with those of the lower extremities.

In advanced cases the bone itself is also involved, and separation of the epiphyses is not uncommon, especially at the knee-joint. Hæmorrhages into the mucous surfaces are very common, the gums being specially affected.

Senator[1] made a very complete investigation of the blood in one case of scurvy. The blood showed a marked diminution in the erythrocytes, which advanced from day to day, until the number was reduced to one-sixth of the normal. Concurrently with this diminution, the hæmoglobin percentage fell to an even greater degree. There was a steadily advancing leucocytosis with diminution of the lymphocytes; poikilocytosis was observed, with polychromatic degeneration of the erythrocytes and the appearance of normoblasts. Megaloblasts were only found on one occasion. The percentage of albumin in the blood-serum was from 5·5 to 6 per cent., an amount considerably below the normal. Cultures of the blood in nutrient bouillon failed to yield any bacterial growth. The post-mortem examination corroborated the clinical evidence of extensive hæmorrhages and advanced anæmia. The microscopic examination of sections and smear preparations from the

[1] *Berliner Klinische Wochenschrift*, April 23, 1906.

spleen and lymphatic glands showed that there was no deviation from the normal structure and no change in the cellular contents. The medullary substance of the vertebral bodies was red, and the same appearance was observed in the epiphyses of the femur, whilst in the diaphyses the colour was yellow. Erythrocytes were present in notably diminished numbers, and consequently the proportion of white corpuscles was greatly increased, but no individual types of white cells were found in excess of the normal proportions.

Clinical Features.—The symptoms of scorbutus in an advanced case are characteristic. The limbs are extremely tender; the infant cannot bear to be touched, and screams or shrieks at the slightest pressure on the long bones.

In the early period of the disease the soreness is indefinite, but when scorbutus is established this symptom cannot be missed, for the mother, nurse and all concerned are struck by it. Its earliest manifestation is usually in connection with the knees and ankles, or the immediate neighbourhood of these joints.

The gums are not, as a rule, affected unless teeth have appeared. As, however, the disease does not usually appear till dentition has occurred, the gums are affected in most cases. They are greatly swollen, sometimes to an extraordinary degree, so as to completely obliterate the natural outlines; they are of a purple colour, spongy in texture, and bleed on the slightest friction or spontaneously. The greatest swelling is found in the middle of the upper jaw in the region of the central incisor, and the teeth may be obliterated from view.

The infant is pallid and cachectic and the tissues are easily bruised. The limbs, especially the legs, are swollen, owing to subperiosteal hæmorrhage. The posture of the infant is suggestive. It lies in its cot looking very helpless and sad, its legs are kept quite motionless, and almost every voluntary movement is avoided, on account of the

pain involved. Occasionally, in the worst cases, this apparent paralysis is due to separation of the epiphyses.

Anæmia is always present, and sleep is fitful and disturbed, sometimes being almost absent. The urine may contain albumin.

Hæmaturia may be a prominent symptom. In certain cases the signs and symptoms above described may be very slightly marked, and blood in the urine forms the only prominent feature. This is of comparative rarity, but it should be remembered that of infantile hæmaturia scorbutus is probably the commonest cause.

A case was recently seen which illustrates this point. An infant, twelve months old, had suffered for about six weeks from intermittent hæmaturia. It was anæmic, pallid, and fretful. The limbs were not swollen, but the left femur was tender on moderate pressure. The gums were rather dark in colour, but were not swollen, nor did they bleed. The food of the infant had been consistently heated to boiling-point or thereabouts.

Both the usual medical attendant and a surgeon had been at pains to establish the cause of the condition, and the question of a calculus had been discussed. As the condition appeared to be due to scorbutus, the infant was ordered fresh milk, raw-meat juice and orange juice. The recovery was rapid. The hæmaturia entirely ceased in ten days, and the infant made very satisfactory progress in health and weight.

Treatment.—The treatment of scorbutus is essentially dietetic. The food must be fresh and unheated. But as milk is of comparatively weak antiscorbutic power, the disappearance of the disease is slow unless the products most powerful in this direction are added to the diet.

The juice of fresh ripe fruit appears to possess the antiscorbutic property in the highest degree. As a rule, the juice of oranges or lemons is generally available, and but little difficulty is experienced in inducing the infant to take any desired quantity. Indeed, it is remarkable that the physiological need seems to be illustrated by the appetite, for it is very noticeable that scorbutic infants usually take these juices with eagerness and relish.

For an infant of six months, the juice of two or three oranges or lemons may be given each day. Other fruits are useful, such as grapes, greengages, plums, apples and pears. All possess the required property, and it is sometimes advantageous to change the precise kind of fruit used in the diet. Care is necessary to ensure that no part of the fruit is decomposed and that the juice is carefully strained, so that none of the solid constituents are given.

An objection to the use of fruit-juice is sometimes raised on the ground that it is liable to incite diarrhœa and otherwise disturb the digestion. This may be the more feared, as in most cases digestive disorder is already present. These considerations should not be allowed to hinder the free supply of the materials essential to cure. The digestive disorders rapidly disappear in correspondence with the other scorbutic symptoms.

When the scorbutic symptoms have disappeared, it is a mistake to continue the administration of fruit-juice. Many cases have occurred in the author's practice where orange-juice produced striking benefit; then the infant ailed somewhat, and equally striking improvement was seen on the withdrawal of the fruit-juice. These juices contain large amounts of citric acid, and their continued use is by no means beneficial.

Raw-meat juice is a valuable agent. In addition to providing the necessary element of fresh food, it assists in the cure of the anæmia and of the cachectic condition.

While the cure of the specific condition of scorbutus is readily obtained in most cases by the regulation of the diet on the principles above described, the infant is often somewhat feeble and delicate for a considerable period following the disappearance of the scorbutic symptoms. The general condition at the termination of the acute symptoms requires careful management. As a rule, the digestion is weak, the circulation is feeble, the blood is greatly deficient in hæmoglobin, and the nervous system

is unstable. These conditions must be met by careful adjustment of the diet. Raw-meat juice is extremely useful at this stage, and the milk mixture should contain as high a proportion of fat and proteins as can be tolerated by the infant's digestion.

Cases of advanced scorbutus are comparatively rare, but cases showing the earlier signs are quite common. In these latter cases the tenderness is not acute, but is sufficiently marked to prevent the infant from moving its limbs at all freely. This symptom is very commonly seen, and has been described as 'pseudo-paralysis.' The following case illustrates the general features of a case of early scorbutus, and the importance of realizing their meaning:

A. G, a female infant, aged nine months. The author was asked to see this infant, as the parents were much alarmed in regard to its condition. For some little time it had been ailing, was not sleeping well, and symptoms of gastric and intestinal indigestion had gradually increased. The infant was in the best possible circumstances as regards care and attention, and the nurse was extremely conscientious and anxious about the baby. Latterly the parents and the nurse had been much alarmed, as the infant did not move its legs or feet. Its right foot was kept quite motionless. The appetite was poor, and the infant suffered from flatulence. The motions were green and curdled. It had been seen by a physician, who had given a very guarded prognosis, and had evidently regarded the cause as primarily connected with the nervous system. No sign of subperiosteal or other hæmorrhages could be found, nor could any history of superficial hæmorrhage be elicited. At the base of the teeth was a purplish margin, not raised above the surface, not spongy, but sufficiently distinct to be definitely outlined from the adjacent tissues. The infant showed none of the signs of acute tenderness; it permitted gentle manipulation of the legs without protest; but on the right leg being gently gripped it cried somewhat feebly, whereas it made no sign when the left leg was grasped with considerable force. The motionlessness and flaccidity of the lower extremities, the purplish margin around the base of the teeth, the slight but definite tenderness of the right leg, together with certain gastro-intestinal symptoms and the general appearance of the infant, led the author to make the

diagnosis of scorbutus. Forty-eight hours after this diagnosis had been made, bleeding from the gums occurred.

The recent diet had consisted of milk mixtures, to which had sometimes been added Imperial Granum and sometimes Mellin's Food; the food had invariably been raised to the boiling-point in the course of its preparation.

The infant was placed on a modified milk unheated, and was given the juice of two oranges daily. After a few days, in which the digestive disorder gave rise to some trouble, the infant made rapid progress, and in less than three weeks had made a complete recovery.

This case is noteworthy because the symptoms of localized tenderness were not marked. On the other hand, the lower limbs were so atonic as to suggest some organic lesion of the muscles or nerves. Hence this condition is likely to lead to serious error in the diagnosis and prognosis of the case. It is necessary, therefore, to bear in mind the fact that this pseudo-paralysis is a feature which is very commonly seen in scorbutus and is uncommon in other diseases.

It is also well to bear in mind that infants often suffer from the deficiency of the antiscorbutic element in their food without presenting the well-marked signs of advanced scorbutus. These cases are generally found when the greater part of the food has been heated, so that the necessary element, though not altogether absent, is markedly deficient. Lack of appetite, indigestion, alternation of restlessness with languor, are the symptoms which the nurse sums up by saying that the baby seems 'very poorly.' Such symptoms as these are, of course, not limited to scorbutus, but they are suggestive. In such cases the only feature at all characteristic is the cry, which is of a whimpering, unhappy character and is seldom vigorous. It is not altogether unlike the cry of atrophy, but is distinguished by the fact that early scorbutus is generally found to occur in infants presenting superficially the appearances of being well nourished. When the condition rapidly yields to fresh unheated food and orange or lemon

juice, the cause is clear; it can seldom be definitely diagnosed until the experiment has been tried. These cases are extremely common and their cause is far from being generally appreciated.[1]

The two cases following are of especial interest, since they show the incidence of the disease in twins where the history of feeding was the same in both cases, and the author is not aware of any recorded cases at such an early age:

S. C., male infant (twin), admitted to the Infants Hospital February 26, 1904, aged three months, weighing 6 pounds 4 ounces.

History.—Breast-fed for six weeks. Then the mother's milk failed. Up to this time the infant had thrived. Then fed on Mellin's Food, with milk and water. As it did not thrive, milk and barley-water were given. Motions pasty; vomiting frequent. Stomatitis and severe excoriation of the buttocks were present.

Treatment and Progress.

	Per Cent.
℞ Fat - - - - -	2·00
Lactose - - - - -	6·00
Whey proteins - -	0·75
Caseinogen - - -	0·25
Alkalinity - - -	5·00

Eight feeds of 3 ounces. Interval, 2½ hours.

March 1: Weight stationary. Not satisfied. Motions improving. Feeds increased to 5 ounces.

March 4: Has gained 2 ounces. Motions yellow, undigested. Taking well.

March 8: Has lost 3 ounces. Vomited twice. Motions yellow.

March 11: Weight stationary. Motions normal. Not taking well. Orange-juice, ʒi *bis in die*, ordered.

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[1] In the first edition the author suggested the term 'scorbutoid' for these cases, and the late Dr. Henry Ashby proposed the term 'parascorbutus.' These terms are of interest, since they have drawn attention to the condition. But, on further consideration, the author is not disposed to multiply the terminology. The difference is, essentially, one of degree; the disease is the same.

March 15: Has gained 7 ounces. Motions yellow. Taking well.

From this time progress was continuous, and on April 12 the food was as follows:

		Per Cent.
℞	Fat - - - - -	3·25
	Lactose - - - -	6·00
	Whey proteins - -	0·75
	Caseinogen - - -	0·50
	Alkalinity - - -	5·00

Seven feeds of 6 ounces. Interval, 3 hours.

April 22: Infant discharged, weighing 8 pounds, 7 ounces.

A. C., male infant (twin-fellow of the previous case), admitted to the Infants Hospital February 26, aged three months, weighing 5 pounds 3 ounces.

History.—History of feeding the same as in foregoing case. Motions like putty. Much vomiting. Buttocks raw and eczematous.

Treatment and Progress.

		Per Cent.
℞	Fat - - - - -	1·00
	Lactose - - - -	5·50
	Whey proteins - -	0·75
	Caseinogen - - -	0·10
	Alkalinity - - -	5·00

Eight feeds of 3 ounces. Interval, $2\frac{1}{2}$ hours.

March 1: Motions yellow. No vomiting. Not satisfied. Has gained 3 ounces.

		Per Cent.
℞	Fat - - - - -	2·00
	Lactose - - - -	6·00
	Whey proteins - -	0·75
	Caseinogen - - -	0·25
	Alkalinity - - -	5·00

Eight feeds of 4 ounces. Interval, $2\frac{1}{2}$ hours.

March 4: Motions yellow, undigested. Taking well. No vomiting. Has gained 1 ounce.

March 8: Motions yellow, undigested. Weight stationary. Not taking well.

March 11: Motions normal. Not taking well. Eyes discharging. Orange-juice, ʒi *bis in die*, ordered.

March 15: Orange juice taken eagerly. Taking well. Motions yellow. Has gained 5 ounces.

From this date the progress was practically continuous. On April 12 the food was as follows:

		Per Cent.
℞	Fat - - - - - -	3·25
	Lactose - - - - -	6·00
	Whey proteins - -	0·75
	Caseinogen - - -	0·50
	Alkalinity - - -	5·00

Seven feeds of 6 ounces. Interval, 3 hours.

April 15: Infant discharged, weighing 7 pounds 1 ounce.

These two cases present a striking demonstration of the scorbutic condition.

On March 11 the author had to determine the reason for the absence of progress in both infants. The motions were normal, there was no vomiting, and, generally, it appeared difficult to account for the want of response to the diet. One symptom greatly influenced him in making the diagnosis. The want of appetite shown by the infants 'not taking well' is an important indication. Without otherwise altering the diet, orange-juice was ordered in each case, with remarkable effect. The first infant was, on March 11, 1 ounce less in weight than it was on admission (February 26). The second infant's weight was the same as when it was admitted. In the week following, one infant gained 8 ounces and the other gained 9 ounces.

In contrast with the above instances, one case may be cited illustrating the severity of the disease when fully developed:

A male infant, aged twelve and a half months, was first seen by the writer in April, 1903. It was stated to have been a fine, healthy child at birth; no reliable evidence as to its birth weight could be obtained For the first two months it was nursed by its mother; after this it was fed on one of the preparations known as humanized milk. As this did not agree with the infant, a patent food was then used, and as the infant continued to be unwell various forms of patent preparations were resorted to. The mother stated that at the age of six months it seemed to be making progress, at eight months it seemed again to be

ill, and from this time its condition altered very much, the infant sometimes seeming to be well, at other times being 'very poorly indeed.' In the last six weeks it had become very much worse.

The infant lay in its bed extremely apathetic and barely conscious. Its face was ashy gray in colour, the respirations were extremely frequent, the pulse-rate was 144 per minute, and the temperature was 103·2°. When touched it moaned feebly, and made no attempt at movement. The mouth was kept open, the lower jaw hanging away from the face. There was a complete absence of muscular tone, so that the infant appeared to be quite incapable of voluntary movement.

The mouth presented a horrible appearance. No sign of the teeth could be discovered, though it was stated that several had appeared. All that could be seen was a purple mass, which was so extensive that on superficial inspection it was difficult to distinguish between the upper and lower jaws, despite their wide separation. Scattered over this purple mass were areas of necrosing tissue, the odour of which was extremely unpleasant.

Petechial hæmorrhages were distributed over the back and limbs, and a large patch of extravasated blood was found in the region of the left hip.

Tenderness, manifested by moaning and by the facial expression, was present in all the limbs.

There was a general enlargement over both humeri throughout their length ; the ulna and radius did not appear to be thus affected, but the index-finger of the right hand was enlarged, especially at the junction of the metatarsal bone with the first phalanx, the enlargement being at each side of the joint.

In the legs the signs were extreme. At both knee-joints the skin was tightly stretched over the swollen epiphyses ; the tenderness also was greater than at any other part.

Bleeding from the gums and nose had occurred ; no history of hæmaturia could be obtained. The motions were semi-solid, green, and offensive. During the last twenty-four hours the infant had refused food.

The infant was so ill that it was difficult to decide what form of treatment was the most urgently indicated.

In order to stimulate the infant, 6 ounces of normal saline solution were injected in the tissues near the right axilla, and to this the infant made a distinct response. The gums and the necrosing patches were then gently sponged with a warm solution of boracic acid. The juice of a lemon mixed with twice the quantity of water was then given by

means of a spoon, and was retained. A modified milk according to the following prescription was obtained within three hours, and the infant was fed with this by means of a spoon, as sucking was out of the question :

	Per Cent.
℞ Fat - - - - - -	1·50
Lactose - - - - -	7·50
Whey proteins - -	0·90
Caseinogen - - -	0·15
Alkalinity - - -	10·00

Unheated. Twelve feedings, each containing 1 ounce.

The juice of one orange (or lemon) diluted with either 1 or 2 parts of water was ordered to be given every two hours, before feeding. As the infant showed marked preference for lemon-juice, this was given instead of orange-juice.

On the next day the infant seemed brighter and more conscious of its surroundings, though it still moaned a great deal ; but it occasionally cried, and seemed to be suffering from pain.

The motions were normal in consistence, less offensive, but still green. The temperature was still high (102·4°), and the pulse was 120. The colour of the face was gray, the mouth seemed to be rather worse, and the odour was extremely offensive.

As the infant seemed to be suffering from sapræmia due to absorption from these putrefying surfaces, it was decided to make an attempt to remove as much of the septic material as possible.

The necrosing surfaces were scraped and were then swabbed with hot boracic solution. This little operation was not attended with any serious bleeding, as where any hæmorrhage ensued this was controlled by pressure; but, nevertheless, the infant suffered from shock, and 6 ounces of normal saline solution were injected into the tissues of the left axilla with marked benefit. One drachm of brandy in a tablespoonful of water was given by the mouth. Half an hour after this the infant was fed. On the third day of treatment the infant showed marked signs of rallying, the pulse fell to 100, and the temperature to 99·8°. The odour from the mouth was scarcely noticeable, and the general condition was distinctly improved. It was now not satisfied with the amount at each feed, and this was increased to 2 ounces.

On April 6 the swelling of the gums was much less, but the infant was restless and cried much. During the following days a marked change took place. The crying became almost incessant. It could not bear to be touched, and the nurse experienced the greatest difficulty in attending to its requirements. The lemon-juice was now reduced in amount, as it was thought that the large amount given

might be producing these effects. But the suffering was not lessened. It was clear, having regard to the general improvement in the condition, that the infant was now suffering from the pain which had previously been in abeyance owing to its almost unconscious condition. As it became more intelligent this feature increased, so that it showed apprehension if anyone approached its cot.

On the tenth day the gums had receded sufficiently to allow of the teeth being seen, and the swellings in the limbs were diminished, while some of the petechial hæmorrhages had disappeared and the others were much less obvious. The patch on the left thigh had completely disappeared by the fourteenth day. On the sixteenth day the first signs of deliberate voluntary movement of the limbs appeared, in the shape of movements of the hands. About forty-eight hours afterwards the infant moved its feet. From this time the progress was rapid. The signs of disease rapidly cleared up, and the gain in weight was remarkable, being in one week as much as 18 ounces. It was now able to take a milk mixture according to the following prescription:

	Per Cent.
℞ Fat - - - - -	3·75
Lactose - - - -	7·00
Proteins - - - -	2·00
Alkalinity - - -	5·00

Five feedings, each containing 9 ounces.

The baby now showed distaste for lemon-juice, and would not swallow it. It, however, did not refuse orange-juice in water, and the juice of an orange was given every other day until the twenty-fifth day, when it was discontinued. From this date progress was continuous, and at the end of the sixth week of treatment, on May 20, the last occasion on which the patient was seen by the author, it was doing well and was quite happy.

Occasionally scorbutus and rachitis are seen in the same subject at the same time. In such cases the scorbutic symptoms should first be dealt with. When these have disappeared, the rachitic condition should be treated. It is, however, remarkable that cases where both diseases are well marked in the same patient seem to be extremely rare. The diet responsible for the development of scorbutus is frequently of the character associated with the worst cases of rachitis, yet the two

diseases are rarely combined in anything like the same degree. A severe case of scorbutus may show on recovery from this disease some of the signs of rachitis, but they are very slightly marked in comparison with the severity of the scorbutic symptoms. *Per contra*, it is rare to see a well-marked case of rachitis in which any of the symptoms could be ascribed with certainty to the incidence of scorbutus. It would seem that in some way the expression of dietetic defect in the one form interferes with its expression in the other form.

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THE END

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